# Teaching of Science By Using Local Resources

**INSTRUCTIONS FOR MAKING THE APPARATUS AND SETTING UP EXPERIMENTS**

Department of Education in Science and Mathematics
National Council of Educational Research and Training

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# Preface

The National Policy on Education adopted by the Government of India recommends that science should form an integral part of general education for the first ten years of schooling. One of the major recommendations of the National Council of Educational Research and Training is that the child should learn the method of inquiry in science and should begin to appreciate science and technology in the life and world around him. The Council recommends that in the primary classes science should be taught as Environmental Studies. This is intended to make education in the Primary School more meaningful by relating it to the environment and day to day experiences of the learner—the child. This has led to the conclusion that more efforts should be made to help the teachers in making use of the environment in the learning/teaching of science. This can be done by providing suitable instructional materials to enable a teacher to make best use of the learning situations which already exist in the environment, in addition, the teachers can be educated in setting up simple improvised apparatus by making use of the local resources to demonstrate [illegible] science.

Certain amount of spade work has been done in Department of Education in Science and Mathematics. Two national level workshops have been organised at the NCERT to develop instructional materials and propagate this idea at the State level.

This booklet is based on the materials developed in those two workshops and on the book "Primary Science Experiments With Local Resources", produced by Mr Keith Warren, UNICEF Consultant.

The purpose of this guide is to help primary-school teachers to engage children in science activities without any specially supplied apparatus. It uses material commonly available in everyday life. The activities and improvised apparatus are based on the needs of the NCERT Primary Syllabus in Environmental Studies. All activities are arranged under the important concepts such as measurement, heat, energy, electricity, etc

It enables teachers following that course, or a similar one, to perform many of the necessary experiments.

Much of the book is written in words addressed directly to children, which teachers can read out to pupils. Children will be able to make most of the items by looking at the photograph and reading or hearing the description. Most of the things can be made quite quickly during a science lesson or at home. It is almost as useful for the children to make the apparatus as to use it for experiments. The use of objects from common life has the advantage of showing children that science is connected with real life It is intended to indicate through this booklet, how a teacher or pupil can use local resources to create situations for demonstrating some scientific principle and to observe what is happening. If this idea can be furthered, it will provide immense opportunity for our school children to learn science from real life-situations and experiences.

We should thank all the resource persons and participants of the two Workshops for their contribution towards the preparation of the instructional materials and Dr B. D Atreya (Reader, DESM, NCERT) and Dr. O. L. Orekhov (UNESCO Expert. DESM, NCERT), who edited these materials and prepared this booklet for the primary teachers for making the apparatus and setting up experiments.

Any comments and suggestions to improve this booklet will be most welcome.

New Delhi

1977

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in Science and Mathematics
NCERT

# CONTENTS

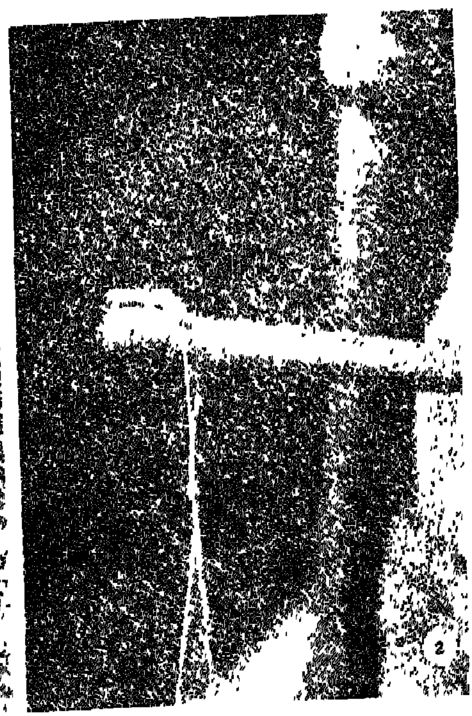
# Measuring

## Measuring Weight

*A Balance*

Children ! Let us make a balance out of a stick and string and thick paper or strong leaves

The most important thing is to make the two lengths of the stick equal, from the middle string to the end strings. Make small cuts in the stick to keep the string in the right place (photos 1 and 2).



Look carefully at the photos to see how the boy has made his balance. (photo 3)

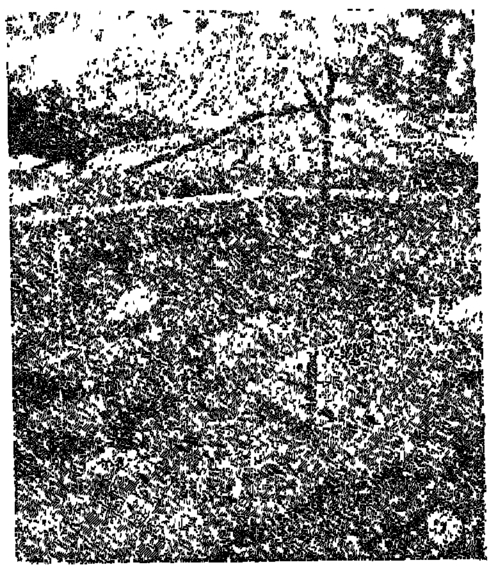
After you have finished it, the stick will not stand level, but do not move the strings. Wrap some wire round the end of the stick that is too high, or fasten some clay there, or wrap a stone there with some string until the stick is level with the pans empty.

You can use a rough or uneven stick to make a good balance, but you must always keep the lengths equal (photos 4 and 5). So, make sure you put the small cuts in right place at first and put the string in the cuts.

*Weights*

Use seeds or nuts as weights, all of the same size. They are not exact weights but they will help you to understand all the ideas about weighing. Clay balls are better weights. Make some.

Set up an imaginary shop, using sand as rice and stones as vegetables. Tear up sheets of paper as money or use leaves if you have no paper. Weigh out the rice and vegetables to your customers.



Instead of holding your balance, hang it from a support. Invent a support, as the boy has done (photos 6 and 7).

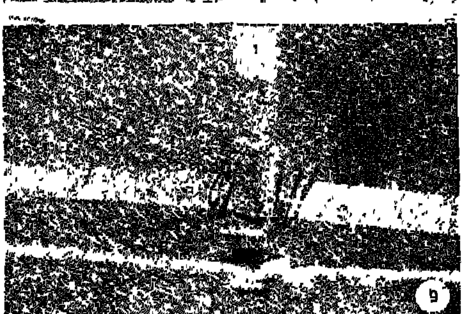
*A Hang-up Balance*

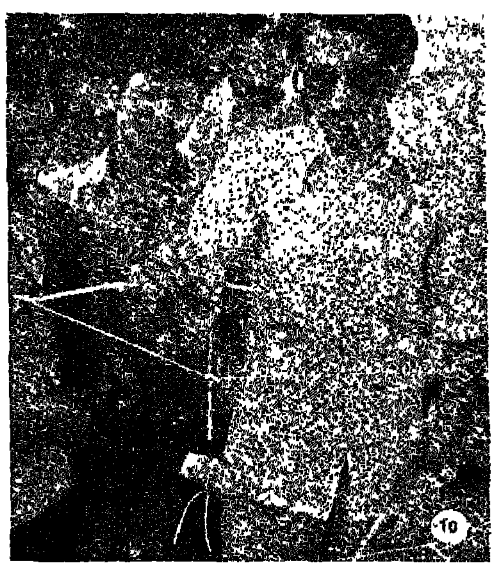
## Measuring Forces

### *A Bamboo Spring Balance*

Children ! Make a device for measuring forces—pushes and pulls—using strips of bamboo, a length of string and two bits of wire The device looks like a bow and arrow (photo 11) You can see how to make it by looking closely at the photos.

The "bow-string" can be fastened by knots to the end of the "bow", but it is better if you cut small slits down into the ends of the "bow" and have knots at the end of the string so that you can easily take it apart as shown in the photo 8 The "arrow" is fastened to the middle of the "bow—string" either by a knot or by wrapping a thread The "arrow" slides through a small wire loop at the middle of the "bow" The photo 9 is a close-up view of how the loop is fastened to the "bow" You need to squeeze it firmly with pliers, or carefully pressing it with a stone Make sure the arrow can slide easily, through the loop Make a hook of wire and fasten it to the end of the "arrow" by wrapping it tightly around Make some grooves in the wood so that the wire will not slip

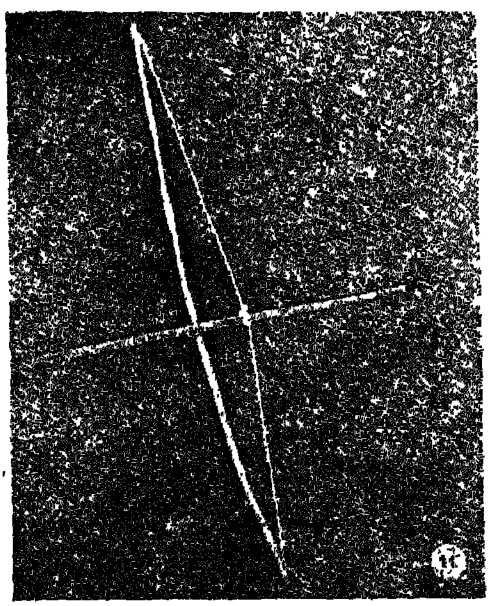


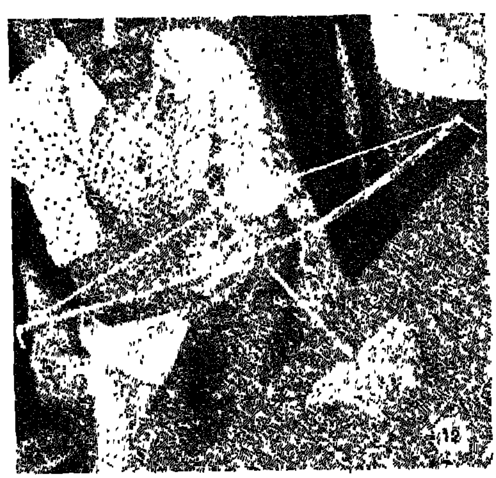


When you hang something from the hook, the arrow moves down (photo 10). Before you put anything on the hook, make a mark on the arrow near the wire loop. That is the mark for "no weight". Next, you must mark the weight or force measurements. Improvise weights (seeds or stones) and use them for marking the arrow. To hang them on the hook, you may need a pan and strings as with the other balance.

Now you can weigh other things. Also, you can measure forces of pull (by pulling with the hook) or forces of push by pressing with the other end of arrow as the teacher is doing in the photo 12. He is measuring how much force is needed to push a stone across the table. So he is measuring friction.

You can use any sort of springy wood to make this force measurer. If the "bow" you made, is thick, it will weigh many kilos. If you make it very thin, it will weigh a fly.





## Measuring Length

*With Your Hand*

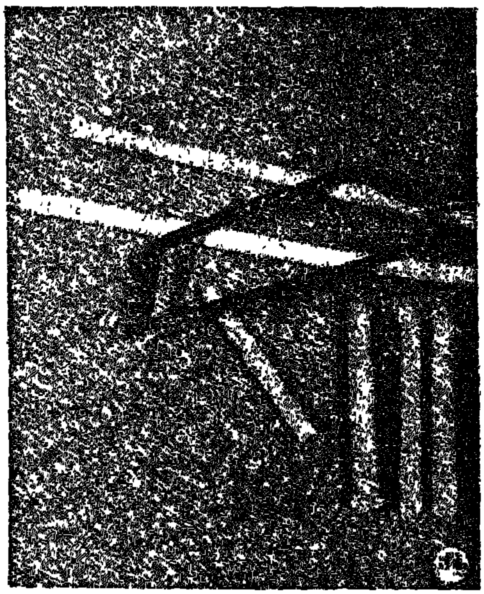
You can measure things in "handspans" as in the photo 13. This is often useful for quick measuring when you have no ruler and you do not need to be very accurate. Carpenters sometimes use this method when they are looking for suitable sizes of wood in a woodyard. Of course, if you have measured your hand-span on a ruler, you can use your hand.

*Use Cut Sticks*

If the teacher cuts some sticks exactly 10 cms long, using it as a ruler (photo 14), each person in the class can have one to use it to measure with You could then use the teacher's ruler to mark the ten single centimeters on your stick.

You keep turning your stick end-over-end along the thing you want to measure, remembering how many stick-lengths it all adds upto, and noticing, how many single centimeters are left when another stick length will not fit in. Measure your height.

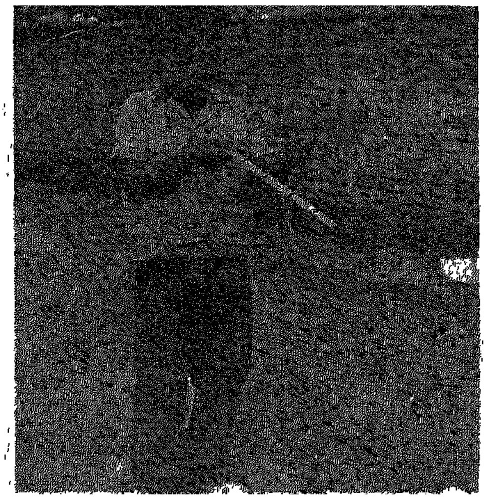
To measure big things, such as a room, you need a stick cut to one metre length marked every 10 cm.

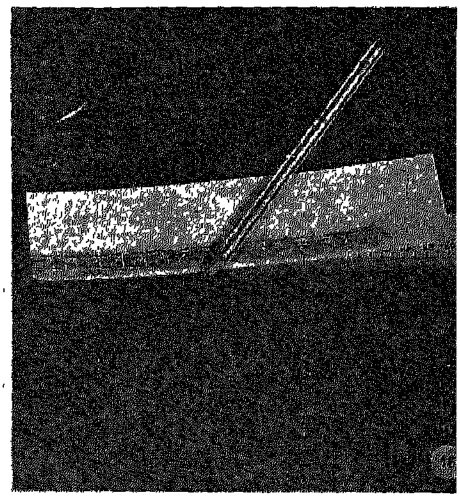


Or, you could use a piece of string a metre long with knots in it at every 10 cm (photo 15)

*Make A Paper Ruler*

If you have only one ruler in the class, and yet each pupil wants one, see whether the ruler has markings which are cut into the wood or plastic. If so, hold a strip of paper on the ruler and rub over it with a pencil. You will see the markings come on the paper (photo 16). So, you have made a paper ruler and you can even see the millimetres on it





*Things To Be Measured*

If you want to measure the lengths of some special solid shapes for a maths lesson, such as cylinders, cubes, balls, etc., make these for yourself, photo 17. A fairly round tree branch, neatly cut at the ends, is a cylinder. And you can make shapes in soft clay and let them dry But notice that clay shrinks as it dries; 10 cm shrinks to about 9 cm.

Growth of a plant may be measured in terms of length. Measure the heights of plants, which you are growing in a glass jar (fig. 18), or bottle, or in plastic bags hung on a wall (photo 19) each day, from root to top. Or, instead of measuring with a ruler, break a stick each day to the length of the plant and fasten it upright in a bit of soft clay At the end of a week you will have a "model" which shows you how it grew. It is a sort of graph.

*A Rolling Measure*

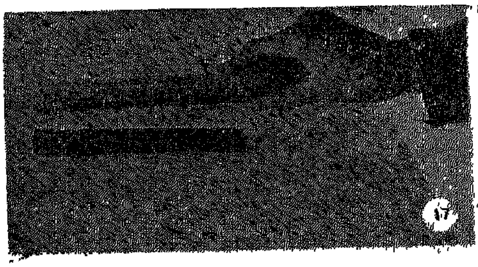
To measure a room or a field, you can use a wheel instead of a ruler. The baby in the photo 20 has a circle of wood (or perhaps it is a tin lid) nailed to a stick. Make one. Then hold the stick in your hand and roll the wheel along the ground which you want to measure Make a clear mark on the edge of the wheel so that someone walking beside you can count how many times it has gone around If you know how long the circumference is, you can find the distance Use a length of string to measure the circumference, then place the string against a ruler

It is best to make a wheel with a diameter of 32 centimeters. Then, its circumference rolls out one metre each time.

**Measuring Volume**

Most match boxes hold 20 cubic centimeters of water. Most packets of 10 ordinary-sized cigarettes will hold 50 cc. of water (photo 22). Block the cracks at the bottom with clay or wax or leave the plastic over on the packet. Squeeze the box sides a little or the water will push them too wide.

So you can put boxful or packetful of water into a cup or bowl or coconut shell (photo 21) and mark the cubic centimeters on the side. If you want to know the volume of a stone, put it into a half-full bowl and see how many cubic centimetres the water rises.



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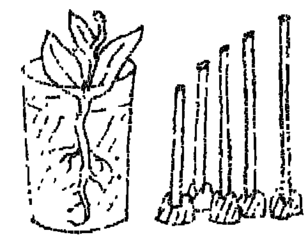

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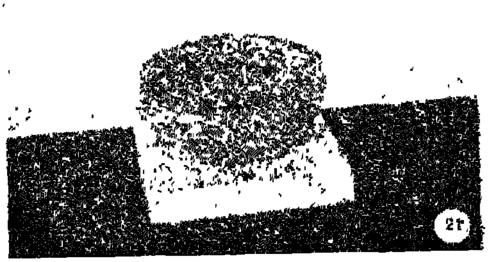

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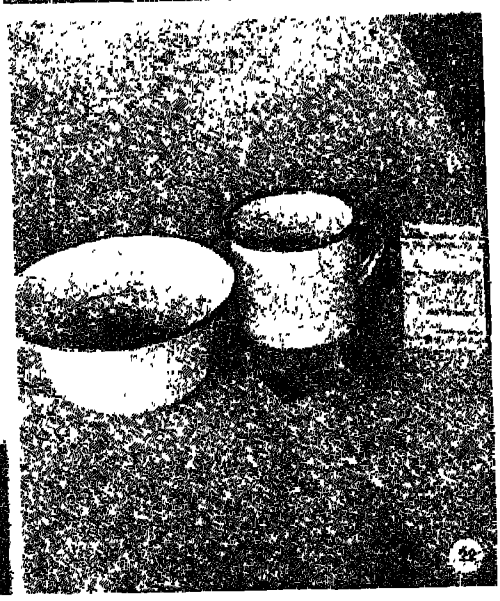

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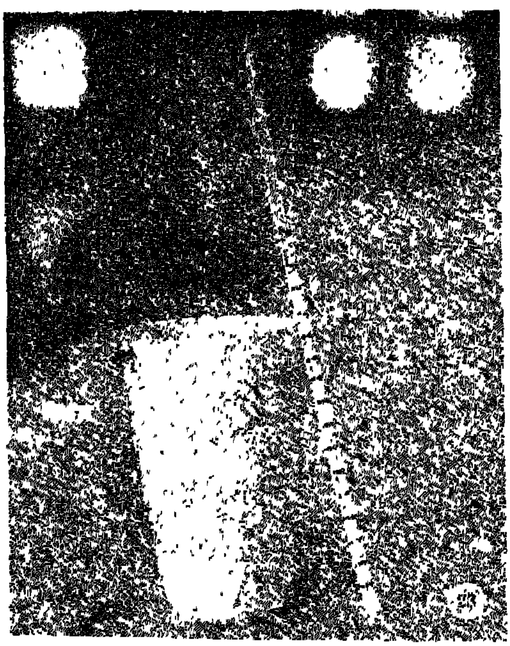
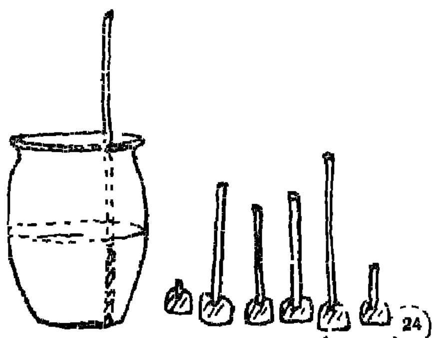
**Measuring Rainfall**

If it is rainy season, you can use the rain for some experiments on measuring.

Put a cup outside at the start of a school day. This is to measure the rain. To do it properly, the cup should have sides which are of the same width all the way down the (bottom) and measure how deep the rain is in the cup by dipping a dry stick in it. Then, take it out and measure the wet part against a ruler (photo 23).

Do this for a week and keep a list of how many millimetres of rain fell in the cup each day. Empty the rain out after you have measured it. Of course, this experiment will not work if only a little rain falls each day because it will be too shallow to measure.



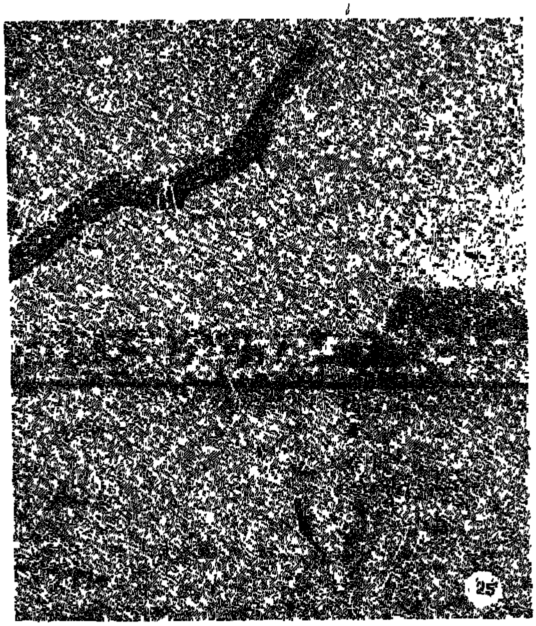


*A Model Of Rainfall*

Instead of measuring the wet part of the dip-stick with a ruler and writing it down, break off the wet part of the stick and fasten it on a window-ledge or other safe place. Do the same thing each day so that you have a lot of bits of stick standing in a line (fig. 24) Each one shows how much rain fell on the day that it was dipped. The drawing shows what this looks like with all the sticks held up with a bit of soft clay or candle wax You have made a scientific model of the history of the rainfall for the week of experiment.

**Measuring Wind**

Children ! Outside, away from buildings and trees, allow a handful of small pieces of paper to fall just to see which way the wind is blowing. You can tell whether the wind is fast or slow by how far the pieces of paper move sideways.




Another way of doing it is to hang a leaf or a feather from a tree by a length of thread (photo 25). It shows wind direction and you can tell if it is fast or slow by seeing how much the feather blows side-ways.

*A Wind Vane*

Another way to measure wind direction is to push a feather into a long straw or light stick (photo 26). Push a pin or thin nail through the middle of the straw. The right place to push the pin through is where the straw and the feather balance on your finger indoors where there is no wind to disturb the balance.

Make a hole with a nail first at that place so that the hole is slightly bigger than the pin and the straw can turn easily.

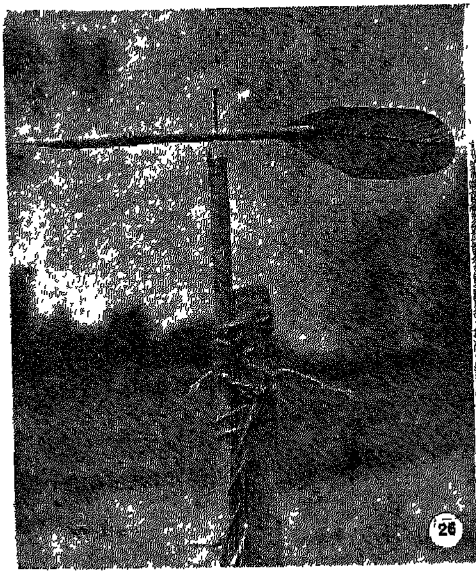
Now, push the pin into the top point of a stick that you have cut to a rounded point like a blunt pencil, and fasten the stick upright on a post or a wall. The rounded point lets the straw move easily without rubbing much on the stick.

*A Simple Wind Machine*

Halve some lemons, oranges or some other fruit with a strong round skin (photo 27). Eat all the middle out of the halves without breaking the skin, so that you have some neat, small "cups".

Then make two thin sticks into a cross and bind them together in the middle with thin wire or thread. Then push the "cups" on the sticks, but not through the middle. Notice in the photo 28 that the sticks go through slightly higher than the middle of the cups. This helps them to hang properly as you find out.

Notice how the cups are arranged : each cup faces the same way, as it comes round to the same position. The middle of the sticks is balanced on a nail-point The nail has been pushed, upside down, into a hole in the support stick. To make it all balance, push the cups nearer to, or farther from the middle. In a gentle breeze, the machine goes round gently, but in a strong wind, it blows off its bearing. The boys in the photo 29 at first tried to fix the long support stick in the ground, but found it was easier to hammer a short stick before that.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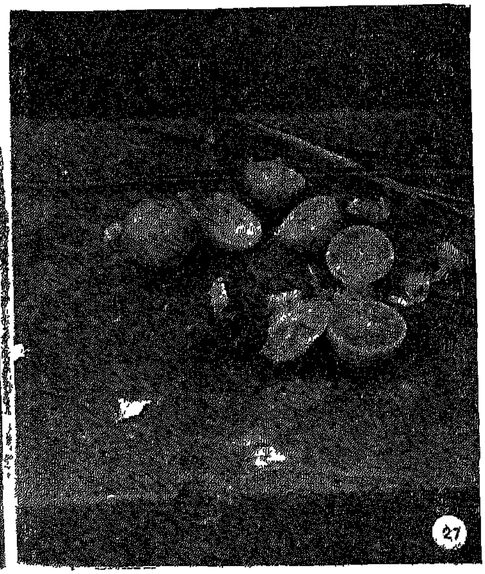
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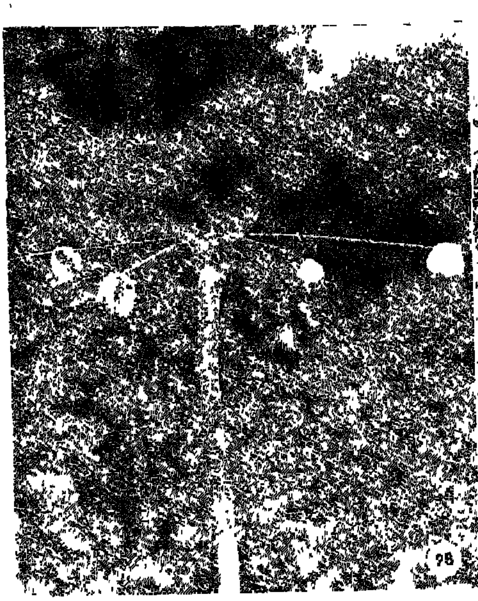
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## Measuring Temperature

### *Judging Hot And Cold*

You can tell whether things are hot or cold by using your fingers, but they do not judge very well. If your hand is very hot and you put it in warm water, your hand seems to tell you that the warm water is cold. Try it for yourself.

Your eyelides are better at judging how hot or cold a thing is. Get some dried balls of clay. Put one ball in the shade and one in the sun for one minute, and a third ball in the sun for two minutes.

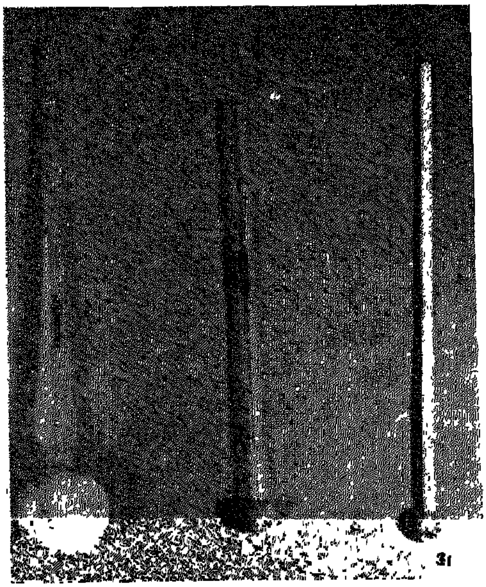
Then take the first and gently press it into your eye socket with your eye closed until you can feel its heat (fig. 30) Then try the second, and then the third. Can you tell which is hotter ?

## An Expanding Air Thermometer

### *Expanding Air*

Children ! On a cold morning, take a cold empty bottle. Wet its mouth and put a wet coin on the top. Next, two children with large hot hands must put their hands tightly around the bottle. After a minute, the coin moves up, lets out some air and then drops down again. It works several times if the

bottle is cold and your hands are hot. The air in the bottle gets bigger as it gets warmer and it pushes the coin up. The water between the bottle and the coin seals the air in.



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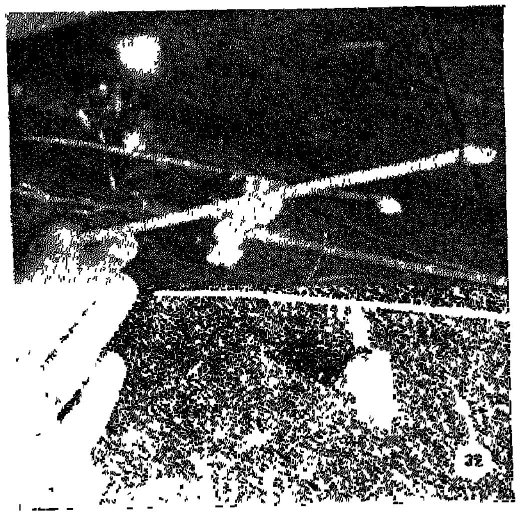

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*Air Thermometer*

Find a piece of thin straw from rice or wheat that has thin sides and is hollow right up the middle like a pipe (photo 31). Make it water-proof by either putting kerosene down it, or warm oil Shake it and warm it in the sun so that there is no extra oil inside it and the pipe is quite clear inside. When it is cool, suck a tiny drop of coloured water into it (coloured with ink, or dye, or clay) and hold the straw level so that the drop rests in the middle. You can see how it should be in the glass pipes in the photograph but you cannot see it well in the straw. Hold upto the sunlight. Then you can see the drop of water.

Next, plug one end of the straw with soft clay to trap the air between the water drop and the clay Now, if you warm the straw over a candle (but do not burn it) or in the sun, the air inside gets bigger and pushes the water drop a little way (photo 32) This is how some scientific thermometers work—by the push of expanding air.

# The Earth and the Sky

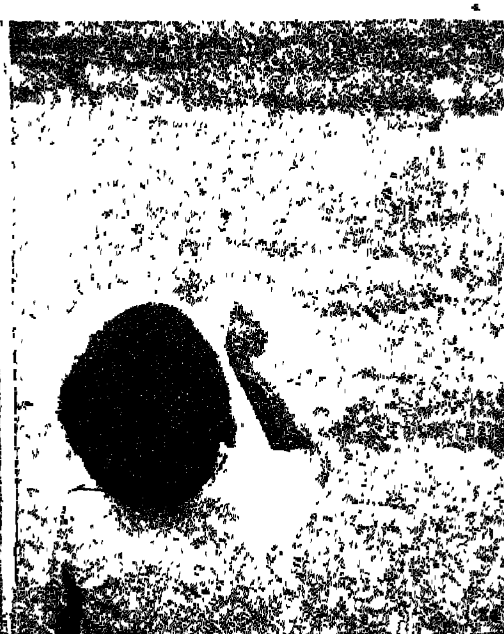
**The Earth And The Sun**

Most diagrams of the sun and the earth in textbooks and charts give children the wrong idea of the sizes and distances But here is how to make a model that is more like the real thing.

Borrow a large water pot and and put it on the ground, neck downwards in a large open space or beside a road. The children at the school in the photograph have placed it out near the village fields (photo 33). Write "sun" on it because this is your model sun, about half a meter wide.

Now make a model earth as a ball of mud, or clay, or a seed about as big as your finger nail, about half a centimetre wide. This is your model earth (photo 34)

Now carry your model earth 50 long strides away from your model sun and hold it up on thick stalk or a bit of wire. So your "sun" is about 50 metres away from your "earth".



This is what the real sun and real earth would look like if you were millions of miles away out in the sky.

But the real sun is a ball of fire and there is neither ground for it to rest on nor anything else around it for millions of miles.

See how small the earth seems and how far apart it is from the sun.

*Make A Model World Globe*

Maps do not give us a good idea of the earth because they are flat. We need to make a model world globe

Here is how to make a model world globe. But first, here is a diagram of the land and seas on the earth Most maps do not show the right shape because they are meant to fit on to a flat page. But this map is drawn to show the correct shapes because it is ready for you to draw them on a round globe.

Choose a large, round clean clay water pot If it has a pattern on it, rub it with a cloth dipped in wet ochre, coloured clay or other paint and let it dry.

The teachers in the photo 35 have done this Now they are beginning to draw in the shapes of the land and sea (photo 36). There are two ways of doing this. In the first way, you draw the equator line round the middle by holding one end of a piece of string on the top of the pot (the North Pole) and you use the other end to guide a pencil to draw the equator. Then get some paint-clay-water, white-wash, or other paint and just start drawing the land and sea on the globe To do this, look at the shapes of the land on the map and look at all the photos from number 37 to 39.

As you paint the countries, you will make lots of mistakes. As you can see from the photos 35-39 the teachers have made many errors But when they realised they had got it wrong, they wiped off that mistake with a wet cloth and tried again. After many mistakes and many wipings off and corrections, they finally got it almost right They also used an atlas or a chart of the world to help them paint the countries and the continents, and they wrote the names of the countries concerned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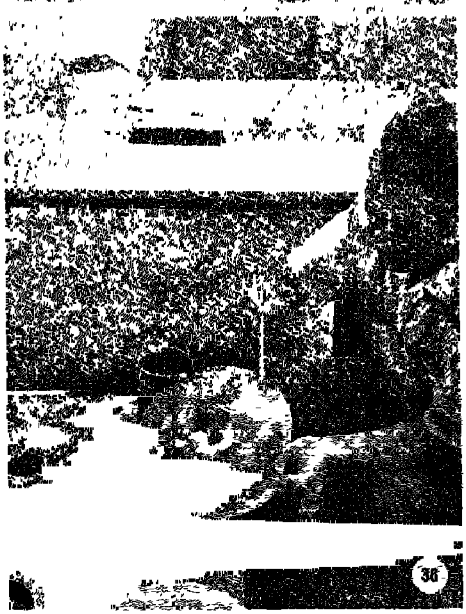
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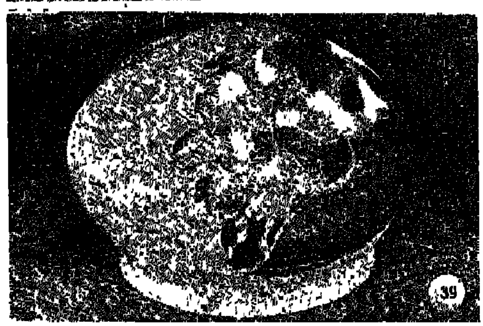
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Often, afterwards, when they were using the globe for a lesson, the children noticed some mistakes that were still there, so, they got a little more paint and made it more correct

The teachers and children considered that in one way it was a better world globe than made in a factory because they had made it themselves, and so they knew the location of each country.

Cut a piece of string so that it will fit round the equator line This is supposed to be 40 thousand kilometres. Perhaps you can use this information and put marks on the string every thousand kilometres so that you can measure the distances from your country to other countries.

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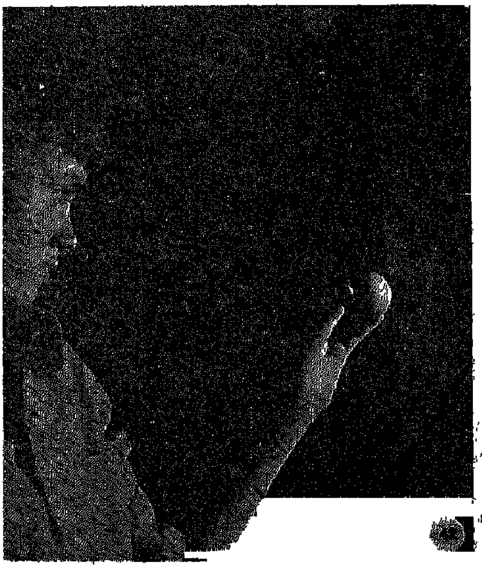
## The Earth And The Moon

### *The Roundness And Flatness Of The Earth*

Find a small broken piece of a large round water pot. Choose a piece about half as big as a match box (photo 40).

The piece looks almost flat on the top and the bottom (photo 41). But it came from a round pot So how can it be almost flat? The children in the photo 40 have been explaining to the teacher that the ground on which their village is built is a very small part of the great round earth.



*Half Moon And The Full Moon*

Take turns to stand near the open door way just inside a dark classroom where the sunlight is coming through the door. Hold a round fruit (photo 42), such as an orange, in front of you so that the light hits it.

The fruit has light on one side but is darker on the other side. If you turn yourself round, keeping the fruit in front of you, sometimes you can see only a part of the lighted side (photo 43).

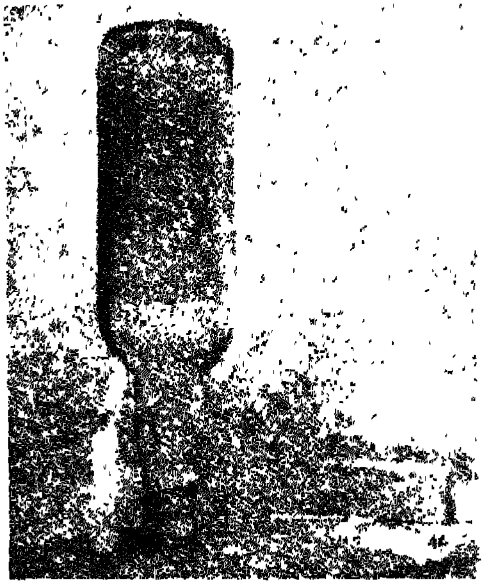
Now, the fruit is like the moon. The moon moves each day, so sometimes you see only part of its bright side. That is why you sometimes see half the moon, or, a quarter of it. The rest of it is so dark that you cannot see it because the night sky is completely dark, like a classroom with no windows.

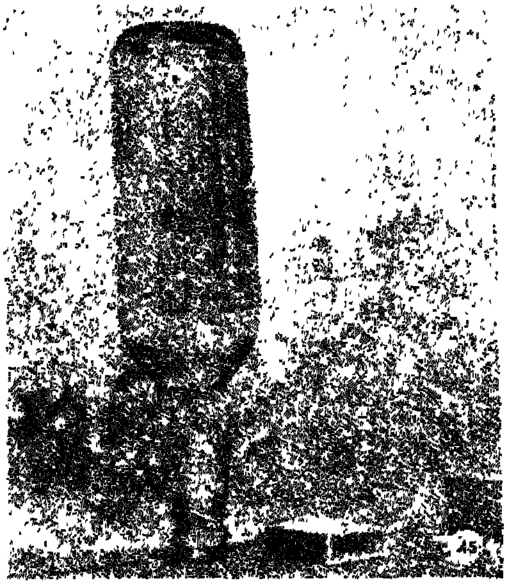
Your classroom is not completely dark, so you can see the dark side of your fruit moon slightly. It is not quite like the real moon in the dark sky.

# Air, Water and Weather

## *Flames Need Air*

Get a candle that is thin enough to fit into the neck of a bottle leaving a little space around it. If your candle is too thick, trim it with a knife until it is thin enough. Light it and stick it down to the table with wax (photo 44).





Then put the bottle over it, neck down, and watch it (photo 45). The flame burns for a little while, then goes out. While it is burning, it is using up something (oxygen) from the air. When it has used it up, it goes out because not enough oxygen can come into it through the small spaces between the neck and the table.

Now, do the same experiment with the candle standing in a shallow dish of water. You will see that water has come in and risen to take the place of the oxygen used up by the burning candle.

*Smoke Rings*

Make a hole as round as you can (or ask a blacksmith to do it) in the bottom of large tin (photo 46). Cover the open end with paper or cloth and wrap it there with string. Get a bit of smouldering cloth or rope and put it through the hole so that the tin fills with smoke

Now, when you tap the covered end of the tin-can, perfect smoke-rings come out of the hole. If you point the tin-can towards your friend, he can feel the smoke-rings hit his face

## Air Pressure And Pipes

*The Effect Of Pressure*

Fasten a length of plastic tubing into the mouth of a plastic bag by binding it with string Put a board on top of the bag, but be sure it has no sharp edges which way burst the bag Then stand on the bag and blow down the tube (photo 47). You will find that you can easily lift yourself. Your blowing pressure has spread out all over the area of the bag and has produced a large force.

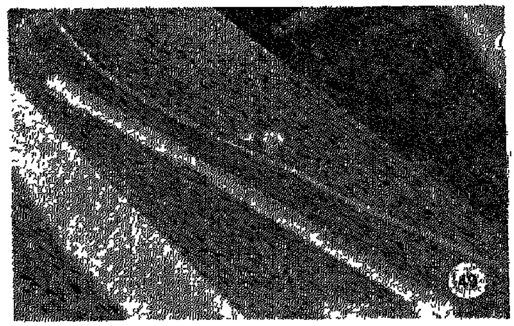
*The Pressure Of The Air*

Press a cup of drinking glass over your chin and mouth. Then suck, so that the cup stays on your chin. The outside air is pressing it on your face because you have sucked some of the air from inside it (photo 48).

*Pipes And Tubes*

Wheat straw, paddy straw, jute sticks, reed and bamboo are pipes that can be useful for sending water or air or steam through as seen in (photo 49). If you do not want water to soak into their sides, put oil of some sort on the inside. You could soak the whole tube, or pull an oily string through it.

If you want a pipe that will bend, use the stem of the leaf of the manioc or paw-paw. If you want a longer pipe, join two of them together with a short length of straw pushed in. It makes only a weak pipe, so be careful. Probably, you know other types of leaves and stems you can use.



Make a siphon like the one shown in the photo 50. (The piece of string is used for keeping it in a bent position). If you suck at the bottom, the water will start flowing from the cup and will keep on flowing after you take your mouth away

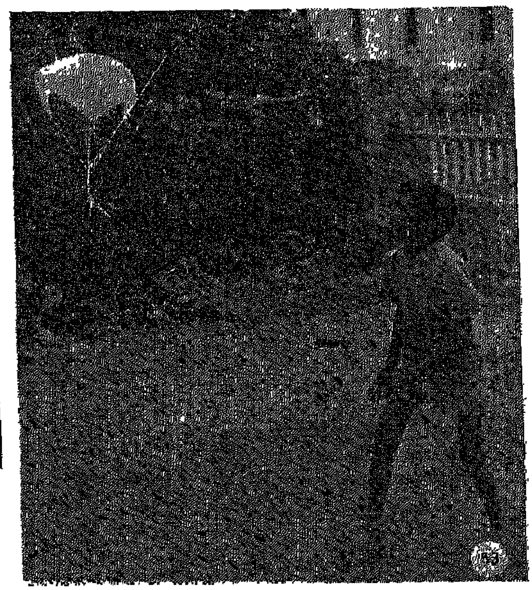
*A Very Simple Pump*

At Holi festivals, children spray water from a bag (photo 51) Use a plastic bag with its mouth bound round a short hollow stem. When the bag is empty, put water into it again by pulling the sides of the bag outwards.

*Make A Helicopter*

Fasten two large feathers to a thin stick with a binding of thread (photo 52). First bind them loosely with a few turns of thread, then twist the feathers into the right position before you bind them tightly.

The feathers must be slightly twisted as you may be able to see from the photo. The left-hand feather (as you look at the photo) is sloping downhill towards you. The right-hand feather is sloping downhill away from you. When you make it correctly, and throw it up, it comes slowly down, twisting round.



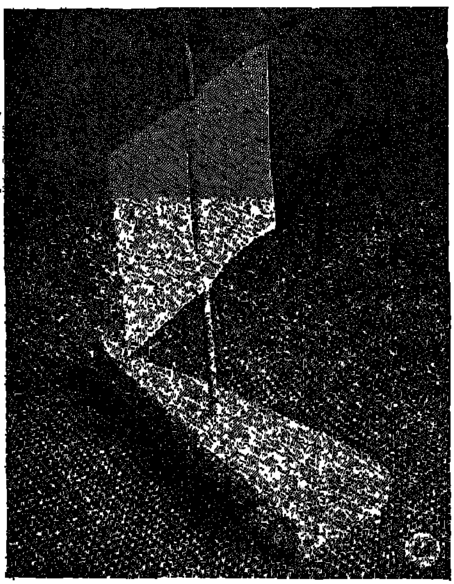
*Make A Parachute*

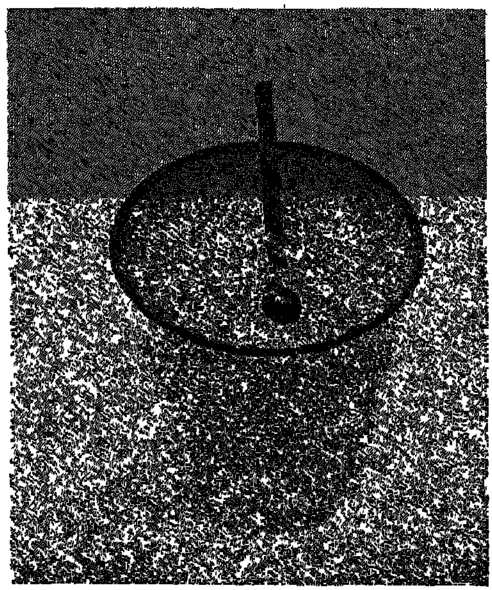
Another way of creating friction with the air to make a thing fall slowly is to attach a large area of thin cloth to it. Take about 25 × 25 cm of the thinnest cloth you can find (or very thin plastic) and tie 4 strings to its corners Fasten the other ends of the strings to a small stone. Wrap the strings and the stone in the cloth and throw it up as high as you can. The photo 53 shows the result

*Make A Sailing Boat*

Moving air will push a boat. Children, make a simple boat like the one in the photo 54. Instead of a paper sail, you can use a leaf. But if it is too heavy, or if you place it too far up the stick, the boat will topple over because there is too much weight high up

You can blow the boat with your breath across a big bowl of water, or you can put it on a pool of water and let the wind blow it along. You will learn about the construction of the boats if you try to design a boat to be as fast as possible and then race it competing with your friends' boats.





*How Things Float In Water*

Try out which substances float or sink. Why does metal sink, while a tin can float? Why does a tin-can topple over unless you put a small stone in the bottom? The photo 55 shows an oiled straw with the bottom plugged with clay. Add clay bit by bit to watch how it gradually sinks in the water in the tumbler.

**Cleaning Water**

*Filtering*

Bend a wire or a split piece (photo 56) of new bamboo into a ring about as big as a bangle for your wrist. Wrap the joint with thread. Stretch a thick cloth over it and stitch it to the ring. This is a filter to take small pieces of dirt out of water, but it does not work very well. It works better if you cover the cloth with a layer of fine sand which you have washed in lots of clean water. Let water trickle through it into a cup.

Better still is a pot with a small hole at the bottom (photo 57). Put in some clean stones at first, big enough not to go through the hole. Then, put in a layer of smaller stones, and then a lot of fine sand. When water trickles through this, it has less dirt in it.

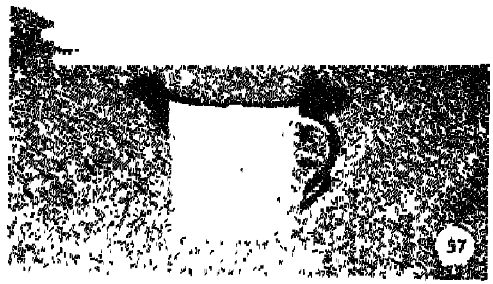
Filtering water like this does not remove germs that cause diseases. To do that, you need to boil it or use a germ-killer. Also, filtering does not take away substances that are soluble in water, like salt, sugar, some colours, etc.

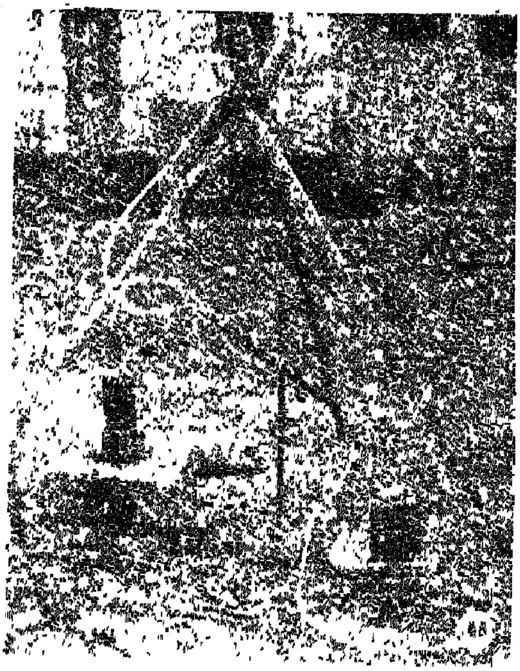
*Distilling Water*

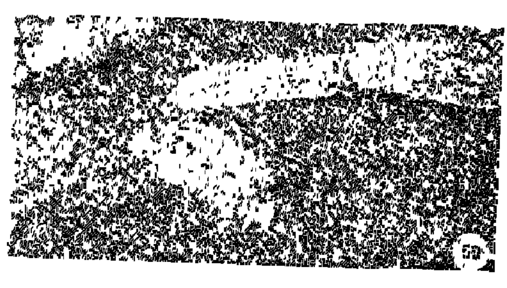
Steam that comes from boiling water is always pure If you cool it to turn it back to water, it has no colour, taste, dirt or salt. In the photo 58, dirty water is being boiled in a bottle, and then it goes along the plastic pipe into a cooler and drips out into the drinking-glass. The cooler is to metal pipes, wrapped side by side with iron wire. Cold water siphons from the bucket through the bottom pipe of the cooler (the upper steam pipe cool) and then spills on the ground.

The bottle-stopper is carved from wood (photo 59) and joined to the bottle by bicycle inner tube (photo 60) held on by rubber bands cut from the double-looped so that they are tight. You do not really need the bit of metal pipe through the stopper to connect the plastic tube. You can just push-fit the plastic pipe into the hole in the stopper.

You can boil water in a bottle if you stand it over the fire in a shallow tin with a few millimetres of sand in a bottom. This spreads the heat and (usually) prevents the glass from cracking. But it would probably be better to make steam in a clay pot, as people do, when they are cooking.







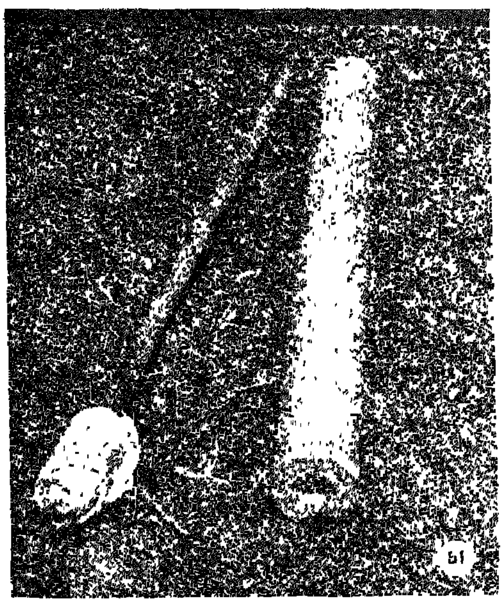
**Pumps**

*Make A Bamboo Pump*

Cut a length of hollow bamboo so that one end is open and the other end is closed (photo 61). Make a small hole with a red-hot nail or wire through the closed end. Now you have made the cylinder.

Make the piston (the pusher) by wrapping the end of a stick with strips of cloth (photo 62). Then push it into the cylinder. It must fit so that it is airtight, but not too stiff to move.

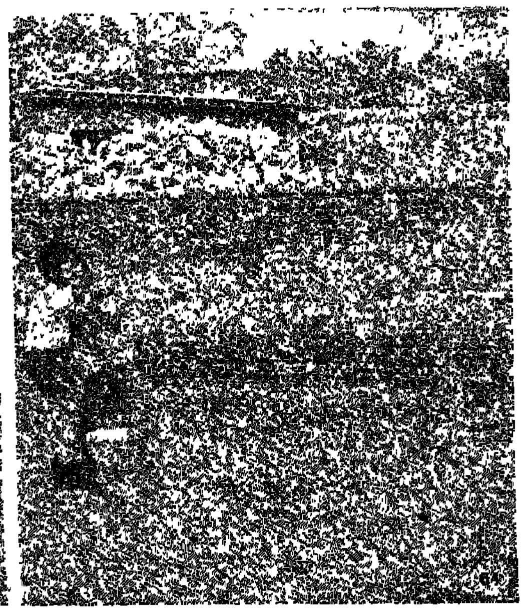
To hold the cloth wrappings on the piston, fasten the ends with a few turns of string. You will need to experiment with the piston until it works well in the pump.



Then wet the pump by plunging it into water (photo 63), so that the cloth round the piston fills with water and it will not let air through.

When you put the end down into a bowl of water and pull the rod up, water comes into the cylinder, and when you push it, it blows out.

Water pumps are very important, and it is necessary to know in a practical way how they work. Most of them are not as simple as the one shown in the photo 64. Real ones have small flap-valves inside, so that water can flow one way but not the other. The pump shown in the photo 68 has a valve to let water come in but not go out.



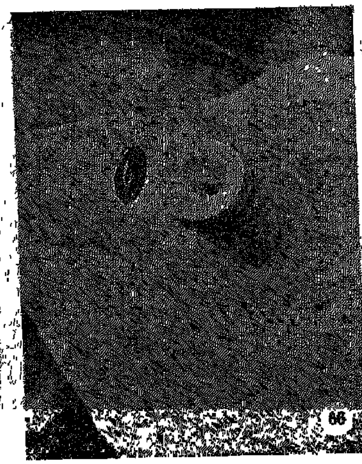
*A Force Pump With One Valve*

This is similar to the pump described earlier. The piston is exactly the same. The cylinder is the same except that it has a hole in the side near the end. Make this hole with a red-hot rod of iron or by rotating the end of a pointed knife. Or, you can ask a carpenter to drill it.

The hole must be wide enough to allow a narrow side pipe to be fitted so that it makes a watertight joint. In the photo, the boy has chosen a narrow hollow bamboo and has trimmed its end with a sharp knife until he can push and turn it so that it jams in the hole in the side of the cylinder (photo 65).

The valve is a circle of bicycle inner-tube rubber with a bit of thin wire through it (photo 66) The wire is bent to stop the rubber slipping off the end. Then, the wire is dropped down into the cylinder, so that the straight end comes out of the hole. The photo shows it upside down


65


66

When you make it, pull the wire gently to make sure that the rubber circle is lying right on the inside of the hole in the cylinder. Then cut the wire off, leaving about 4 centimetres sticking out. Bend the last 2 cm at an angle so that it cannot go back through the hole You can see the bent wire in the photo 65.

The valve can move further into the cylinder (until the wire stops it), so that it opens the hole. So, if you put your mouth to the top of the cylinder and suck, you can hear the valve rise and air coming in, as the boy is doing in the photo 67 (he should have his finger over the hole in the side-pipe). But when you blow, the air pushes the valve down on the hole and the air cannot go through

Now, when you put the end of the pump into the water and work the piston, the pump blows water out of the side-pipe at every downward stroke, photo 68. During the up-stroke of the piston, water does not get sucked along the side-pipe and had a valve also, that allowed flow out but not in.

Sometimes, we need to join pipes for improvisation. Some techniques are given here

*Joining Pipes*

Join bamboo pipes with bicycle inner tube. If the pipes are ordinary-sized bamboo, the inner tube will fit water-tight over them by stretching.

If the pipes are thinner, wrap the rubber on to the pipe with a binding of string (photo 69).

In the photo 70, the boy is trying out the joint in his thin bamboo and is also testing with pump by sucking and blowing.

You can even make three-way or "T" junctions (photo 71) with the bicycle inner tube. To join a side-pipe (photo 72) make a small hole in the side of the rubber tube. Then hold it close on to the wooden pipe and bind it with string until it is water-tight.


69


70


71

# Simple Machines

*Well Pulley*

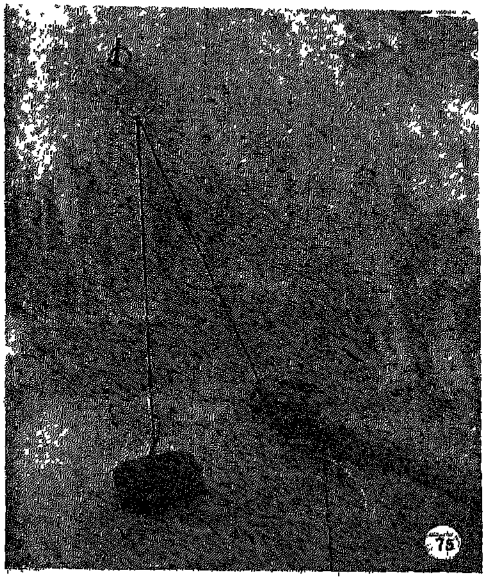
Pulleys used on most wells are of the type shown in the photos 73 and 74. There is perhaps one on a well near the school that you can go to inspect and compare its operation with a wire-loop pulley.

*Wire-Loop Pulleys*

Children ! You can make some pulley like the one shown in the photo 75. Make it by looping medium—thick wire around a stick or the neck of a bottle. You need not make them as neat as shown in the photo. These were made with the help of a pair of pliers to twist the wire tight to make the hook, but this is not necessary.


73


74



The photo 75 shows a "single pulley block". Hang a single pulley block from a tree or a nail in a wall, and use it for pulling up a stone, using a piece of string Can you feel that the string drags on the wire ? This is friction

See whether you can reduce the friction by using wet string or some which you have rubbed with a little ghee or oil. You can use the "bow and arrow" force measurer to discover what pull you need to pull the stone up in each case.

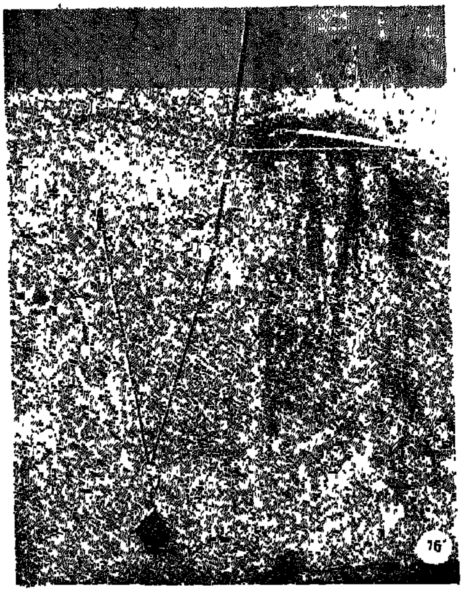
You probably know how wooden pulleys squeak as you haul up a bucket from a well. The squeaking is caused by friction. How do you stop this squeaking ?

**Pulleys And Friction**

*Another Way To Use A Pulley*

Arrange your pulley, stone and force measurer as shown in the photo 76. Find out whether you need to pull the string with a force that is more than the weight of the stone, or of the same, or less weight. Again, try using water and

oil. In the photo, one end of the string is fastened to the force measurer and the other end is tied to a nail in the wall. If you pull the movable end of the string up by one metre, how much does the stone move up? See if you can decide which moves faster.



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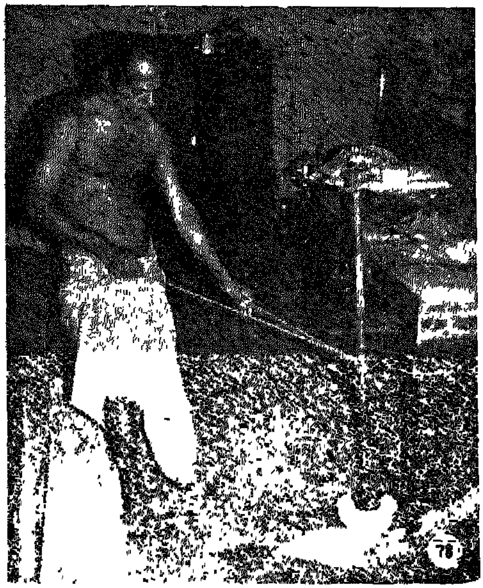
77

*Two—And-Three Pulley Blocks*

Next is photo 77 of a 3—pulley blocks being used for lifting a piece of iron. The photo is not very clear : the part of the string that comes up from the left-hand end of the lower pulley goes out of the picture to the nail fixed in the wall.

Try for yourself various arrangements [illegible] 1, 2-and 3-pulley blocks and see which one gives most [illegible].



*Pulleys Made Of String*

Probably. everybody knows how milk is churned with a stick held to a table-leg or a wall with two rope loops, while the man or woman pulls to-and-fro on a rope wrapped on the middle of the stick to make it turn fast.

The rope loops slip easily on the wood but the wrapped robe has so much friction that it grips the wood very tightly. Try it for yourself with a stick from a tree and three pieces of string and investigate for yourself how it works (photo 78).

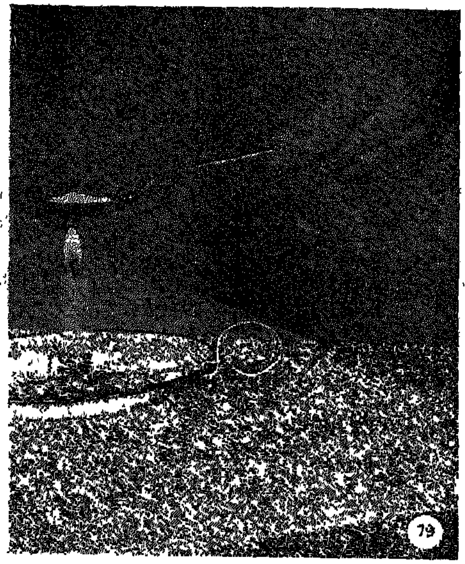
# Heat

*The Simplest Heaters*

Do simple heating experiments, such as heating a powder, or melting a piece of candle wax (photo 79) by using a spoon held over a candle or kerosene oil lamp.

*The Charcoal And Candle Wax Heaters*

The drawings 80 and 81 show a heater that uses candle wax and charcoal.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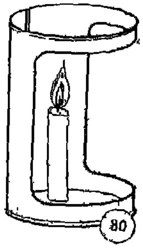
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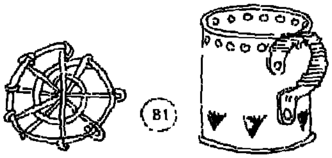
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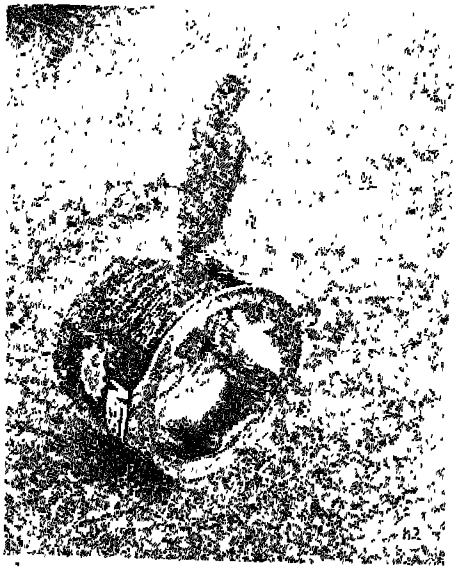

82


83

If you want to stand a dish over the candle, make a support from a tin can. Cut part of the side out of the can with a knife so that the candle can get air. Smooth the cut edges with a stone, but be careful. Most people cut themselves on the sharp pieces of tin can, when they are doing this, (photo 82). If you want to make a charcoal heater, first punch nail holes around the top open end of tin can Then, with a pointed knife, make V-shaped cuts near the base so that you can bend the V-shapes upwards inside so that the fire-support can rest on them. The fire-support is a woven mat of iron wires. Weave it for yourself as shown in the drawing 81. It need not look neat as long as it holds up the charcoal. Put the iron mat into the can and start a small charcoal fire in it. As the air goes in through the bottom holes, the fire soon begins to glow red without smoke or sparks. The best charcoal to use is from hardwood or coconut shells

Stand the heater on a flat stone if you are working on a wooden table. But it is best to use the heater on the floor or a low wall When you have finished using the heater, tip the charcoal into some water to put the fire out. Then put the charcoal outside to dry, so as to be ready for next time you need it.

### *Heating With A Fire*

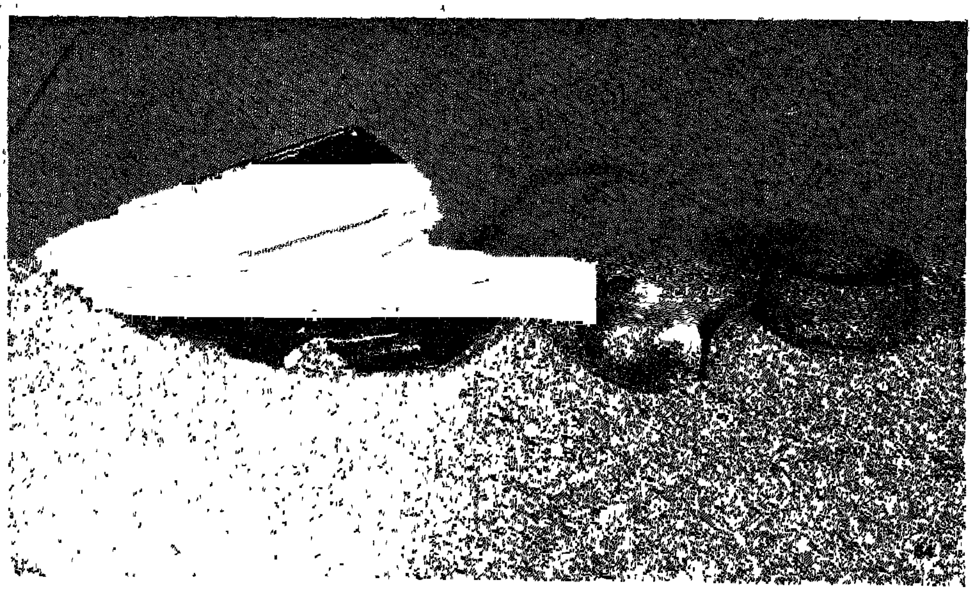
To boil water, use an ordinary fire and a tin can or a pot like the one you use when you cook at home (photo 83).

### *A Powerful Charcoal Heater*

The photo 84 shows the parts of a heater which burns charcoal in a draught of air from a bellows The bellows is a bag (of cloth. paper, plastic or goatskin) with a pipe leading from the bottom The pipe goes through a small hole and is wrapped with string to make the connection airtight. The bag has 2 strips of wood at the mouth so that you can easily close it to make the mouth almost airtight There is a stone in the bottom of the bag to keep it on the ground.

To blow air, hold the strips with your hands and press the strips together so that the mouth of the bag closes. Then, press down so that the air in the bag gets pushed through the pipe. Then, open the mouth of the bag by pulling your hands apart, and raise them so that the bag fills with air again. Keep on repeating this.

Make a small metal dish with a hole at the bottom. Use the metal from a tin can. Cut a circle, cut a sector out and then make a hole in the middle. A blacksmith would do this for you, or you could use old scissors. Then make a clay pot with a hole in the side (to fit the pipe). The pot can be of baked or unbaked clay. Perhaps a potter would make you one. Then, start a charcoal fire in the metal dish and put it on the pot, and pump the air with your bellows. You can boil water over this stove in a tin can, a clay pot or a metal cup.



*Heat From Friction*

Rub your hands together very hard and in quick motions, and immediately put them on your face. Friction can produce heat. Sometimes, the friction can be great enough to make things burn.

The old man in the photo 85 is striking a piece of steel (in the right hand) against hard flint rock which he holds in his left hand.

Bits of steel are rubbed off with so much friction that they burn and set on fire the bit of cotton rope he is holding near the flint stone. The burning bits of steel appear as sparks which settle on the cotton and then ignite it. Then, he blows gently on it until it produces a real flame.

*A Fire Drill*

The next photo 86 shows a boy making a pointed stick smoulder as he presses it on a piece of wood and rotates it rapidly by the method used in churning milk. He has a kind of wooden bow in his hand. Its bowstring is wrapped twice around a stick. The stick is roughly round and smoothly sharp at each end. The top end goes into a glass bottle so that it can turn easily without hurting his hand. The bottom point turns in a small hollow in the wood he is holding down with his knee.

Try it for yourself. Press down hard and move the bow to-and-fro very fast. It is difficult to do, but after some practice you can make smoke. Try different types of wood. Some work better than others. They must be dry. Of course, it is the friction which produces the heat.

*Explosions With Kerosene*

This is something entirely different but still a heat experiment. Many boys will know it. Make a small hole near the closed end of a piece of wide bamboo that is open at the other end. Put a drop of kerosene inside and put a small lighted stick into the small hole. The kerosene vapour explodes. You can see the puff of smoke coming out at the end (photo 87). It works best when it is hot.

*Heat From The Sun*

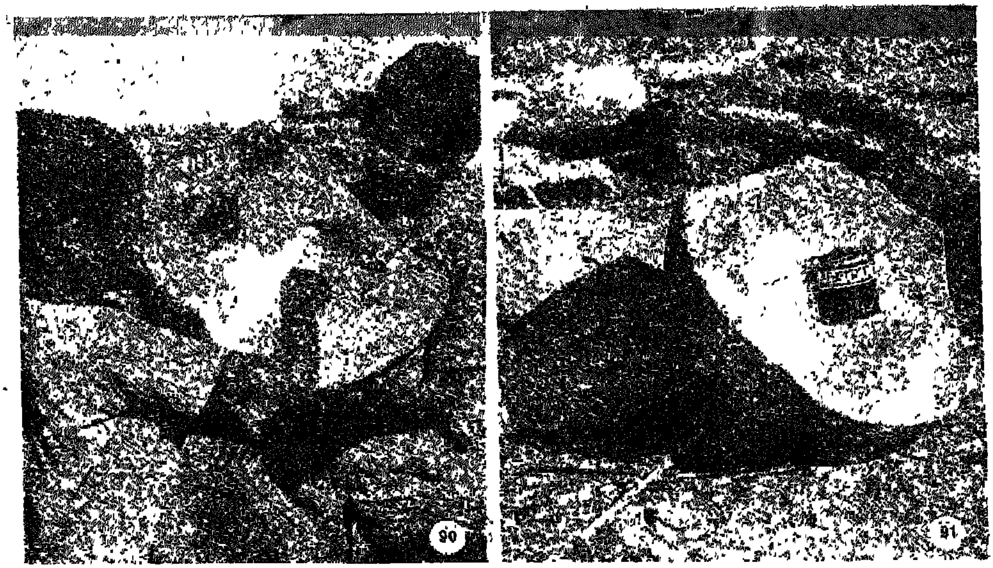
Find a clay pot, as large as possible with a broken top but a complete, round bottom. (or you could use a bowl with a round bottom, but these are uncommon). In any case, it is better to use something no one else wants.

Break off the top parts carefully with your fingers, bit by bit, so that you do not break too far down. The pieces break off easier and more neatly if you break them outwards, not inwards (photo 88).



Collect some of the shiny metal foil from cigarette packets. These are of two kinds. One is nearly as shiny as a mirror. This is the kind you need. The other kind is covered with tiny dots and has a white appearance. This does not reflect sunlight so well Make some sticky paste with flour to act as a glue. (Mix rice or wheat flour with a little of cold water until it is a thick paste. Press out lumps until it is all smooth. Then slowly add water, stirring it well until it looks like milk. Then boil it slowly until it becomes a smooth glue).

Glue the metal foil into the bowl and smooth it down, keeping the shiny side outwards (photo 89). Wipe off any extra glue, or it will not reflect sunlight so well




Then, face it towards the sun and feel how the heat of the sun is reflected and gathered to a position in the middle of the bowl, about 5 centimetres from the surface of the foil The boys in the photo 90 are trying it out on their hands but they have not finished covering the inside with foil.

Support a small tin with water in it at the place where most of the heat appears. The tin in the photo 91 is held with wire pushed through two nail-holes in the top, but the boys have not fixed it in the best place—it is too far away from the surface

Try it for yourself. The water gets nearly too hot to put your finger in Cover the tin can bottom with a thin layer of soot from a candle or kerosene lamp. This helps the tin can to take up the heat better

# Electricity

*Battery, Bulb And Wires*

Connect a bulb to a battery with two lengths of thin iron wire. If you cannot get a good battery, get an old one and press the top off with a knife or a screw driver. Do not break the black rod in the middle. Dig the pitch out and the circle of paper, until you can see the dull black chemicals inside.

Put about ten drops of water in and leave it for a day, so that the water soaks into the chemicals. The photo shows one that has had this treatment and has been connected to a bulb. Hold the wires on the right places with your fingers. Look closely at the photo to see the right places.

If putting water in an old battery does not work, you will have to try to borrow a good one. You can use ordinary iron fencing wire to connect the bulb, you do not need special electric wire.

The battery pumps electricity out from the top end (positive, marked+) and sucks it in at the bottom (negative, marked—).

*Electric Circuits*

To understand more about electricity, you need to connect up bulbs, switches and batteries, so make for yourself some neat devices to make it all clear. You can see how to make them by looking closely at the photos 92-98 on the page 49. Notice that the wire used is the white or grey galvanised fence wire. Make the switch by first drilling 4 holes in a block of wood about 8×4 cm by 1 cm thick and then fit two thick iron wires.

Notice that there are only 2 wires Each one is looped underneath and goes along a saw-cut in the base, so that it will lie neatly on the table.

Make the bulb holder in the same way, but one thick wire lies on the wood so that the bottom of the bulb can press on it. The other wire is long and is first wound round a pencil. Then, you can screw the bulb in (if you have wound it the right size and the right way round). Look closely at the photo 94

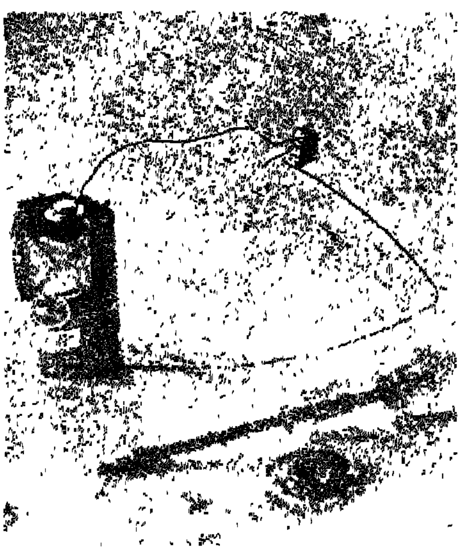
*Connectors*

Keep looking at the photos 95 and 96. You will see that the battery connectors are curls of wire with straight ends. Hold them on to the battery by stretching a thick rubber band, made from a piece of bicycle inner tube, over them and the battery.

To connect the thick wires of the various parts together, get some thin iron wire and wind it into a spring, about one centimetre long, on the thick wire. Then pull it off the thick wire, and bend it slightly in the middle as shown in the photo 97. Now, it will fit tightly on any thick wire you push it on, and let the electricity go through Make four or more connector wires like this, each one about 15 cm long with a spring at each end.

Finally, connect the devices together as shown in the photo 98 You can use one battery cell or two.

When you push the long wire on the switch so that it touches the short wire (photo 93), the electricity can start pumping through and the bulb will light up. If you lift the long wire over the short wire so that it stays there, the switch will remain "on".



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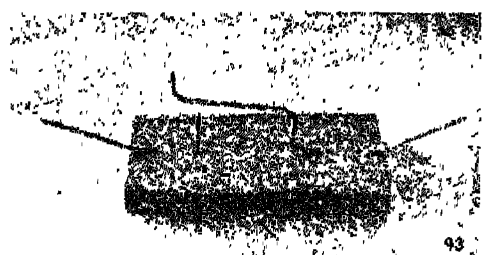

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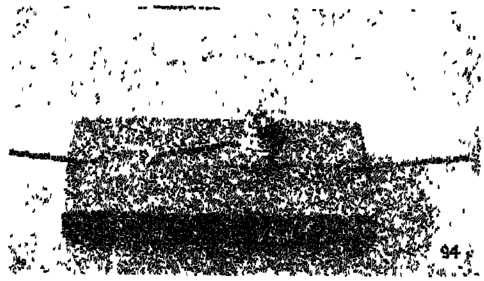

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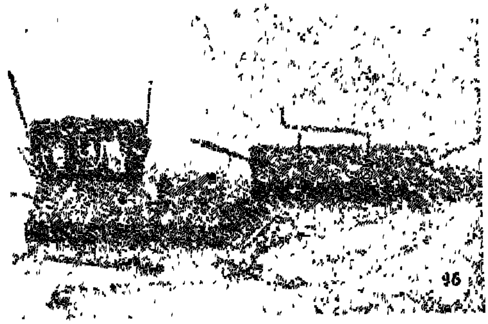

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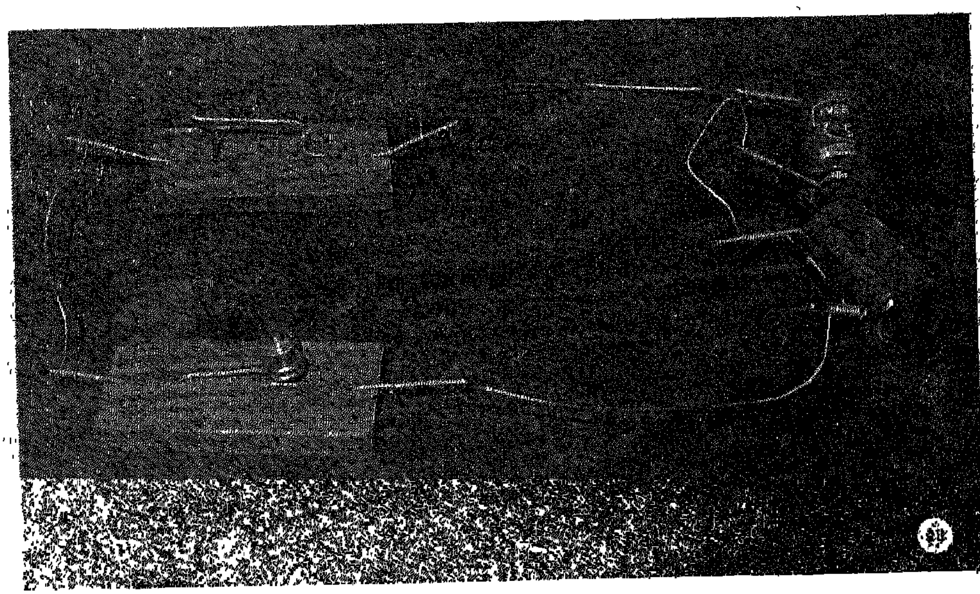


98

# Energy

*Make A Turbine*

If you have made the wind machine, you will probably be able to make the turbines that you see in the photographs 99-102 without needing much written description.

The turbines are made in the same way as the wind machine, but they have an axle attached to the middle. Two types are shown here. One type has eight cups (photos 99 and 101), four spokes and has its axle fastened to the spokes by lashing them all with thread. This is quite difficult to do. It is difficult to keep all the thin pieces of wood in the right place and to arrange the axle at right angles to the spokes.

The second type is much easier to make. As its axle, a piece of the thin wood (broom bristle, coconut palm-leaf middle, or split bamboo) is pushed through a lemon. Then the spokes are pushed into the lemon at the right places and at the right angles (photo 100).

Before the axle is pushed through the lemon, it must be scrapped with a knife. It will thus become smooth and round where your fingers will hold it, so that it can turn easily in your fingers—so must the axle of the eight-cup turbine.

Before the spoke pieces are pushed through the lemon hub or the cups sharpen the ends with a knife to make it easy to push them through.

Instead of holding the axle with your fingers, you can make a rough frame of wire to support the axle ends (photo 101). This reduces the friction considerably.

The turbine goes round fast when you blow hard at the cups, as you see the man and the boy doing in photos 99 and 100.

If you hold it under a gentle stream of water from a tap, as seen in photo 102, in which someone is pouring from a cup, the water will drive it round very well.

Of course, there are many wind-and-water power machines. One that most children know is shown in the photo 103.

**Energy Under Heat Effects**

*Putting Iron Rims On Wooden Wheels*

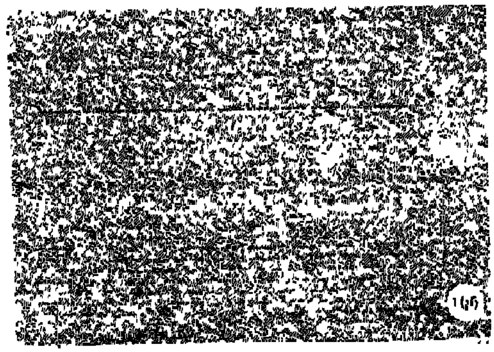
You may have seen blacksmiths putting wheel rims on the wooden wheels of bullock carts. You can see them doing it in the photo 104. First, they take an iron rim which is a little too small for the wheel. Then they heat it in a fire. You can see the ring of fire at the front. The smoke from the fire makes the photo difficult to see. but the blacksmiths can be seen knocking the rim on While the iron is hot, it is bigger and they can knock it on the wheel. Then when it cools down, it shrinks again and holds itself tight on the wheel.

*Heat Makes Wire Longer*

Fix up a wire about 3 or 4 metres long between a nail knocked firmly into a wall and a movable stick (photo 106). Drill a hole near the end of the stick. The hole must be wider than a nail. Knock a nail through the hole into the wall so that the stick moves easily. Fasten a thin iron wire strongly on to the stick about 2 cm above the nail, either by wrapping it round the stick or through a small hole The photo 105 shows how this is done. Arrange the wire so that it holds the stick sloping as shown in the photos 105 and 106.

When the day gets hotter, the wire gets longer and allows the stick to move down a little. On a cold morning, you will find that the wire has shrunk and the end of the stick has moved up. Make a mark on the wall where the moving stick shows "hot" and where it shows "cold". So it acts as a thermometer.


104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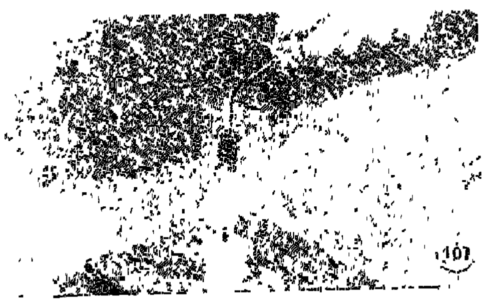
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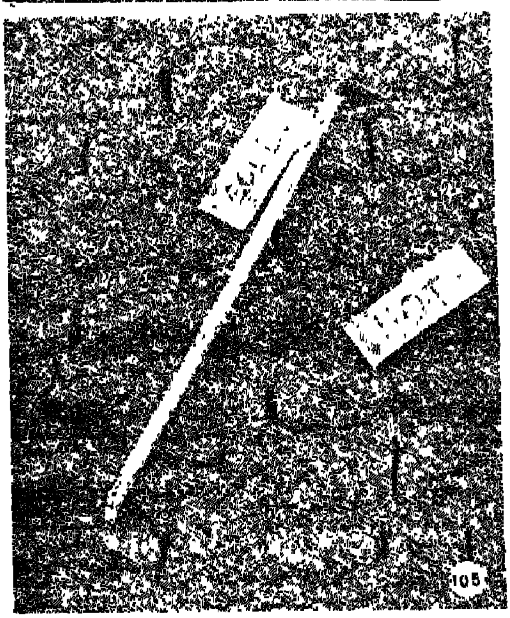
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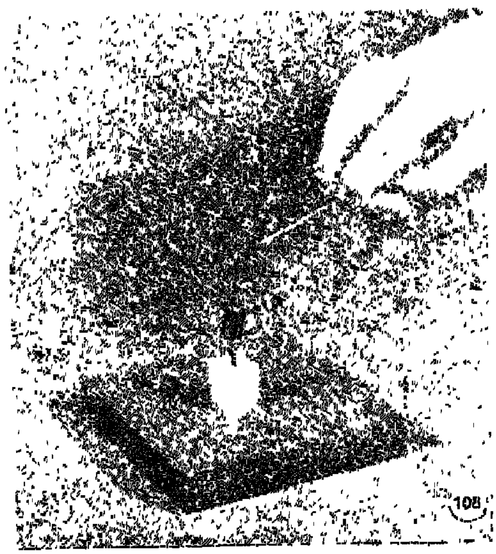

108

You can make it move a great deal by burning a piece of paper or a handful of dry grass under the wire.

### *Metal Absorbs And Conducts Heat*

Wind a piece of thick iron wire around a pencil. Lower the coil of the wire over a candle flame. The iron takes so much heat from the flame and so quickly that the flame goes out (photos 107 and 108).

## Energy And Spinning Objects

### *A Spindle*

The old man in the photo 109 is spinning cotton. He twists the cotton with the aid of a spindle which you can see hanging from his right hand. Photo 110 also shows the same.

He gives it a spin with his hand. This spinning energy lasts for quite a long time because the spindle is hanging from the cotton thread and there is not much friction. But gradually, the energy from the spinning spindle goes into twisting the thread and the spindle stops. Now the twisted thread is like a wound-up spring. It contains the energy. It will give the energy back to the spindle again and make it twist back the other way if the old man does not give it another twist the right way.


*Spin The Liquid Inside An Egg*

Spin an egg as fast as you can in a smooth dish (photo 111). Then catch it for a very short moment to stop it, then let it go again. You will see it starts spinning again. This is because the liquid inside was spinning too and when you stopped the outside, the inside continued. When you let go, the energy from the spinning liquid started spinning the shell again.

Would it work with a hard-boiled egg ?

111

112

*A Spinning Toy*

Most children know how to make one of these. It is a flat bit of wood with two holes in the middle. The loop of string goes through the holes and round your hands. The boy in the photo 112 got sore hands because the string was thin so he held it with bits of wood.

You set it spinning by giving it a push with your nose, then you pull at the strings by moving your arms apart. The wood comes to a stop and then starts turning the other way as the string untwists. It works in the same way as the the old man's spindle, but it is easier to understand how sometimes the energy is in the spinning wood and sometimes in the twisted string. Of course, you are also giving it energy with the pull of your arms.

*Make An Electro-Magnet*

You need to cover your wire to stop electricity going out of the side and into other wires that may be near it.

The photo 113 shows two boys wrapping a length of the iron wire with strips of cotton, winding the strips spirally along the wire so that every bit of it is covered. It is difficult to hold the cloth to the wire in the beginning. It is best to hold it on the wire by binding it with thread for the first centimetre. Or you could put some gum, glue or flour paste on the cloth to stick it.

If you are going to make an electro-magnet, fasten one end of the thin wire to a tree, or to a nail in a wall. Stretch it tight so that there is about 3 metres of straight wire. Then start wrapping. When you get to the end of one strip of cloth, lay the next one on the wire and continue. Make sure it is tight on the wire, or it will slide along and show fare wire The teacher and the boy in the photo 114 have wrapped it tight and well, using thin cloth

When you have wrapped about 3 metres of it in the manner described, you can make a very interesting device.

Wind your covered wire round a very big nail (15 cm), or a thick iron bolt, or other piece of iron The photo 115 shows it done, but the nail in the photo is too small and the children who made this used only one metre of wire, which is too short to make a good magnet. The ends of the wire must be connected to a battery cell. So let each end stick out about 20 cm from the nail

When you hold the ends of the wire on to the ends of the battery cell, the nail becomes a magnet and will pick up small nails. Do not connect it for long because a lot of electricity flows and soon the battery will stop working. As you can see, the wire on this magnet in the photo 116 was covered with strips of newspaper (about 3 cm wide), covered with a little glue and allowed to almost dry before it was wound on the big nail.


113


114

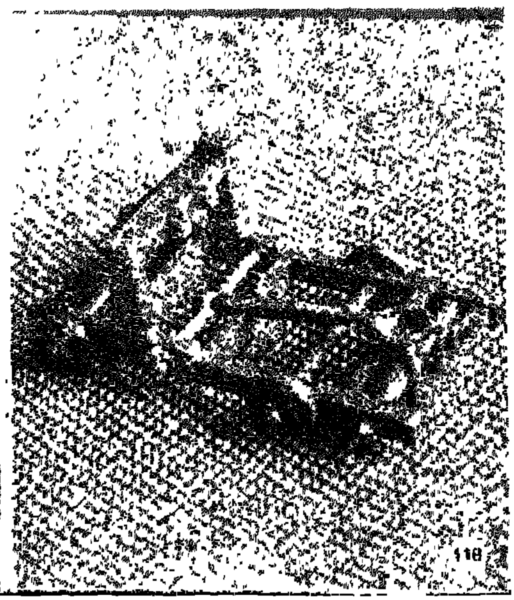

115


116

## Storing Energy

### *A Sling Shot*

The photo 117 shows a boy with a sling-shot made of rope with which he is going to fling stones at the parrots to keep them off the ripening maize crop. He gives energy to the stone by whirling the sling round his head with the stone resting on the doubled part of the rope you can see at the bottom. When the stone has acquired a lot of energy because of its high speed, he lets go off one end of the rope and the stone flies a hundred metres.

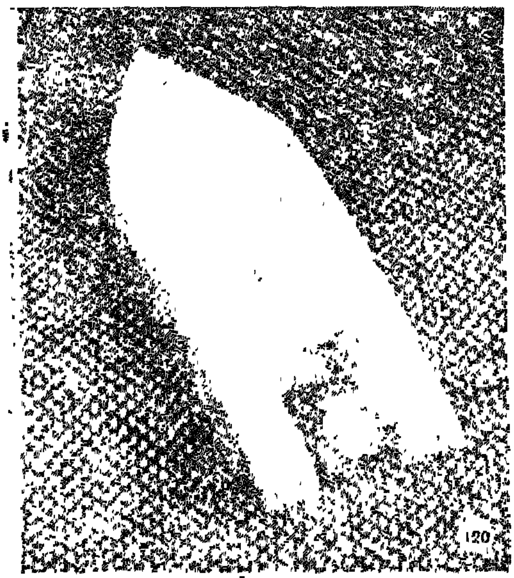

### *A Model Catapult*

The photo 118 shows a beautiful model made by a carpenter. The thing like a spoon is held back by a metal loop which rests over a projection at the end of the spoon. You can move the loop back because the wooden piece it is fixed into can turn on nails through its ends. A twisted rubber band holds the other end of the spoon. You can twist this band with small handles that go through the loop-ends of the band where they come through each side of the frame.

The twisted rubber stores energy. When you pull back the metal loop, the spoon flies up and throws the stone which you have put in the spoon bowl. Now the stone has the energy.

The photo 119 shows a very simple model of the same thing. The rectangular shape at the back is a piece of stiff card or tin nailed on to the base. The square hole in it holds down the throwing-lever. When you pull back the card, the lever slips out of the hole and throws the stone which you have put on the lever. You can see the twisted rubber bands (made of bicycle inner tube) that store the energy. The second pair of nails and rubber is for stopping the lever.

119



120

*A Power Boat*

If you look carefully at the photo 120 you will see the rubber band which has been twisted by turning the bit of flat wood. This bit of wood is the paddle for driving the boat through the water Make one and try it out This time, the energy goes into the forward movement of the boat and of the water, backward

**Energy, Springs And Clocks**

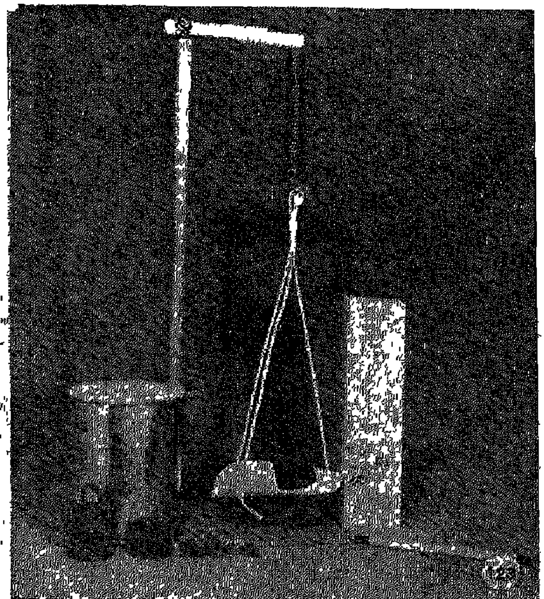
*A Propeller Boat*

The photo 121 shows the boat upside down. Make one like this, but instead of the metal bit for the wire to go through, you could use a block of wood with a hole. Or, you could cut the metal from a tin can and

make the holes with nails. The propeller is a bit of twisted tin with two holes through for the wire. When you wind up the rubber band and put it in the water, it moves fast. If it does not, your propeller is not twisted properly. Keep trying until, it works.

*Make A Spring Balance*

Wind a spring round a piece of wood (photo 122) Use ordinary iron wire. It should, in fact, be steel, but you cannot get steel wire. If you make the spring long and wide, it will work quite well, but do not pull it too far out or it will not go back to its right length. You can see how it is being used with some weights made out of concrete. Notice the simple support stand (photo 123). The tin can is weighed with clay and the wooden arm is bound on with string



The marks on the wood at the side show the weight. If you put a bag of oiled paper on the pan and pour a cigarette packet full of water in, you can mark "50 grams" because 50 cubic centimetres of water weigh 50 grams. Look back to the earlier page for the description of measuring water volumes.

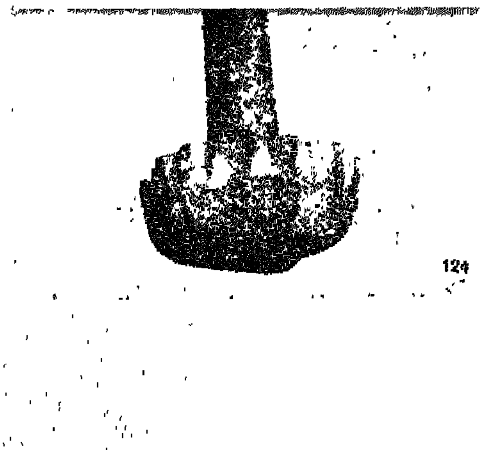
Springs are often used for storing energy—for example, in clocks and watches

# Vibration and Sound

*Make A Vibrator*

Turn a bicycle upside down and gently touch the spokes with a thin stick while you turn the pedals While the wheel turns fast you hear a high, buzzing musical sound. If the wheel turns slowly, you hear a low sounding note. Each time the stick hits a spoke, the air near it gets a "push". The "push" of air reaches your ear and gives it a "push" inside and you hear a "bang" like a small hammer stroke. When your ear gets hundreds of pushes very quickly, you hear a musical note.

If you have no bicycle to use, perhaps you could use a milk-churner. At the bottom of the churning stick are either 2 crossed pieces of wood or a block carved into notches as shown in the photo 124. Hold a bit of stick or a piece of card against this as if someone else turns it, and you will get the same effect as with bicycle spokes. Try it fast and also slow.



124

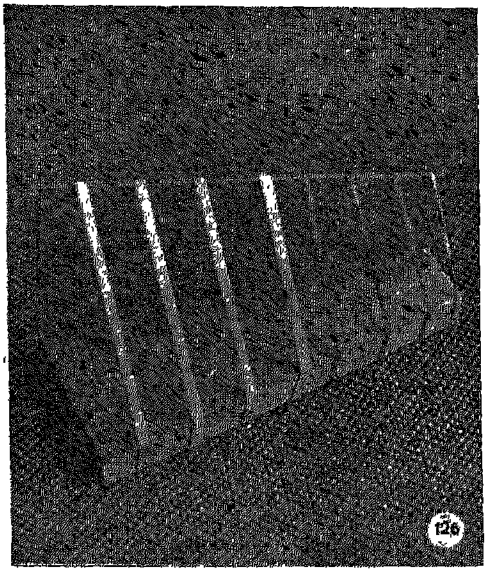
125

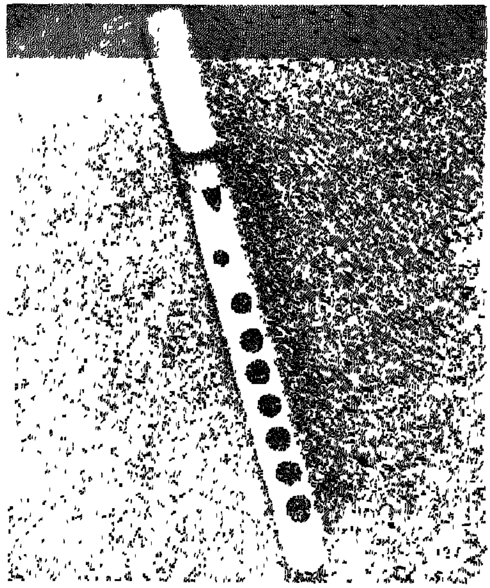
### *A Vibrating Ruler*

Hold a ruler (or other strip of the thin wood) hard on the edge of a table with one hand. Make the other end vibrate by pressing it with your thumb and then letting your thumb slip off (photo 125) Keep doing this rapidly When the ruler sticks a long way out from the table, you can see its end vibrating. Change the length of the ruler that sticks out and do it again. Can you hear the musical note? The ruler is hitting the air just like the bicycle spokes hit the stick.

### *Vibrating Rubber*

Stretch some rubber bands cut from a bicycle inner tube over a wooden frame as shown in the photo 126. The frame is about the size of your hand although the photo makes it look too big Pluck the bands so they vibrate, hitting the air hundreds of times and making a musical note. Stretch some bands tight and others loose to make different notes. Play some music on it.



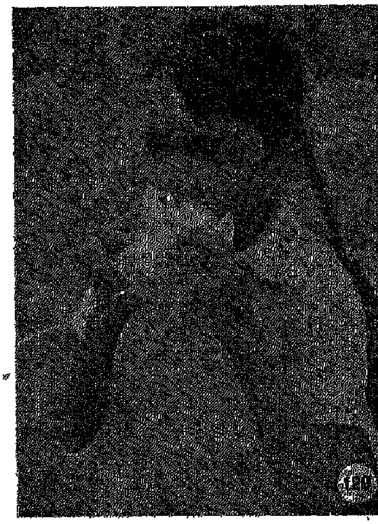
*Vibrating Air*

In a flute (photo 127), the shape and the holes makes the air vibrate even though nothing else moves.

*Make A Tin Telephone*

Cut both ends out of a tin can with a sharp strong pointed knife or a tin opener. Smooth the rough edges with a stone. If you have no tin cans, use short lengths of wide bamboo. They work just as well.

Over one end, stretch some strong paper, and bind it with string. Make a small hole through the middle of the paper and push one end of a long string through it. Then, fasten a bit of the thin stick to the end of the string so that you cannot pull it through the hole Do the same thing at the other end of the long string. You can see how to do it from the photo 128.



Now pull the string tight, holding the tins, with you at one end and a friend at the other. But do not pull so hard that you tear the paper (photo 131).

Now talk into your tin while your friend listens at the other end He can hear your voice (photos 129 and 130).

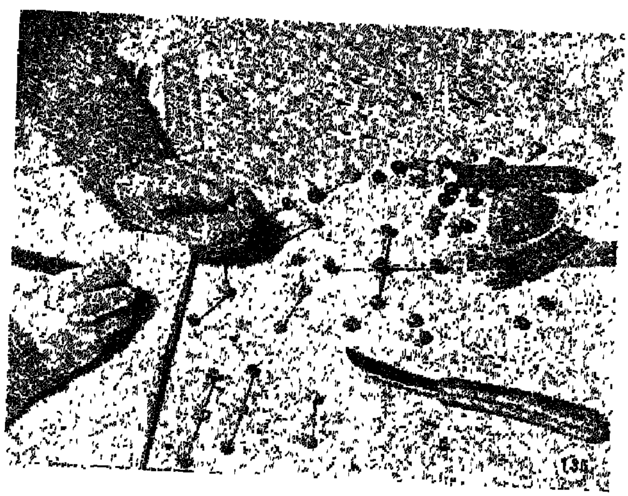
Your voice hits the paper in your tin and gives it hundreds of pushes while you talk The pushes go along the string and push the paper in your friend's tin. His paper hits the air in his tin and this air hits his ear hundreds of times. This is why he hears your voice.

# Using Clay

*Make Balls, Cubes And Other Shapes*

Roll clay balls (photo 132) and when they are completely dried in the sun, use them.

You may need clay balls for making various models, etc. You can also make from clay : cubes—by pressing it flat and cutting with a knife, cylinders—by rolling clay under your hand on a flat stone, pyramids—by moulding with your fingers. etc. You can make discs, model bricks, flat square centimetres to help understand area measurement and cubic centimetres to help understand volumes, etc. You can make moulds to cast wax or lead metal.



*An Abacus*

If you make holes through the clay balls while they are soft, you can make a counting-frame by threading them on wires or strings tied across a frame of wood or bamboo.

The abacus being used by a girl (photo 133) is made of reed bound at the corners with string. It is always best to bind this wood, bamboo, cane, reed, etc , because nails split it easily.

*Make Model Flowers*

Children ! Use clay and coloured paper (or leaves) and small sticks to make large model of flowers (photo 134). You may take two pieces with the needles and inspected with the magnifier This will help you understand what the various parts of the flower are for, and to remember special names of these parts.

*Make Models Of Atoms*

You can use coloured clay balls as models of atoms to make up models of chemical molecules, but that is complicated theory (photo 135).

# Magnifiers

*A Water Drop Magnifier*

Magnifiers are devices made of a clear substance in the shape of a slice of the side of a ball They are generally made of glass, but can also be made of water if it can be made into a rounded shape Drops of water hanging from something are round, so this is what you can use first.

Hang a drop of water from the bottom of a piece of glass. This is quite difficult. Take a piece of clear glass such as a bit of window or a photoframe glass, or a fairly flat piece of bottle, or a spectacles glass. Wash it well with water and soap (if you have some. If not, use wet ashes from a wood fire, but do not rub hard or you will scratch the glass). Do not touch the clean glass surface—just hold the edge. Lower the glass gently onto a high, but small drop of clean water standing on a metal or glass surface, so that the water stick to the underside of your glass. Now use the water that is hanging there as a magnifier to look at something. In the photo 136, someone is looking at a newspaper with a water drop hanging from a spectacles glass. You can look at ants, etc , through it.

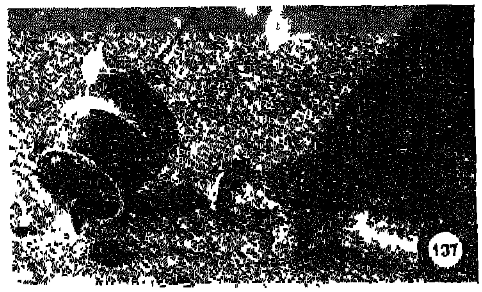
*A Bulb And Water Magnifier*

Find someone who knows how to remove the end and middle from old, clear electric light bulbs. Or, try it yourself. It is not very difficult. Hold the bulb gently in your hand and hit the metal and black substance at the end until you can remove it. Then poke a nail or screwdriver in and crack out the middle glass parts (photos 137 and 138).

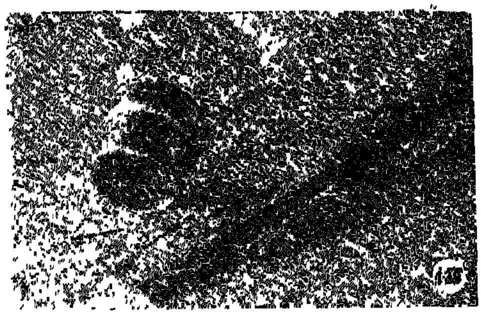
Then wash it out and fill half of it with water. Make some sort of stand for it with wire (or ask a carpenter to make one of wood). Two types of wire stands are shown in the photos 139 and 140.

Look through the magnifier from about 20 cm above it If you get closer, you can see more but it does not look so big. Support the flower, or whatever you are looking at, on a block of wood (photo 140) to see if it looks clearer. You need plenty of light on the flower so make sure it is not in your shadow. Small bulbs, such as 25 or 40 watt ones magnify best.


136



137



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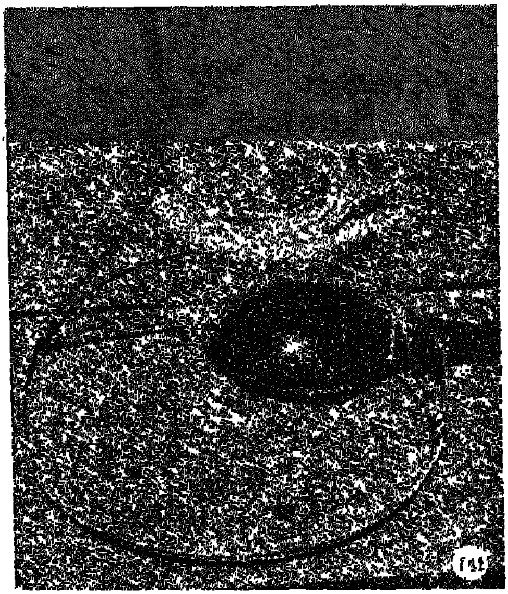
139

140

## Lenses And Mirrors

### *Focus The Sun*



Put your magnifier out in the hot sun around mid-day. You will see that the curved water in the bulb collects the sunlight to a bright spot (photo 141).

Arrange a crumbled, dry, dark leaf under the bulb, so that the bright spot falls on it and is as small as possible. You will see that the leaf begins to smoke and smoulder. The curved water concentrates the sun's heat as well as its light.

The best bulb to use for this is a big one, such as a 150 watt one because it collects more light and heat.

### *Use A Spectacles Glass*

If you can find from some old spectacles a glass that is thick in the middle you can collect the light from a candle and make a picture on a piece of paper, but you must keep on trying until you get the distances right. In the photo 142, the glass is held up by some soft clay. The distances should probably be about one metre from glass to candle and from the glass to the paper In the photo, someone has been using the two magnifying glasses. In the picture, you can also see that distances are too short for the spectacles glass lens.

### *Make A Mirror*

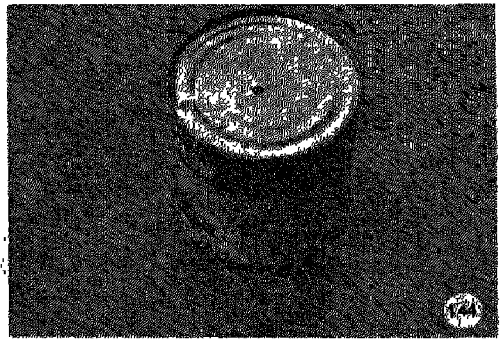
Put some of the most shiny metal foil from a cigarette packet behind a piece of glass and hold it there with card, bound with thread (photo 143). It does not work very well but it will reflect a spot of sunlight on a wall. Make the foil very smooth and clean.

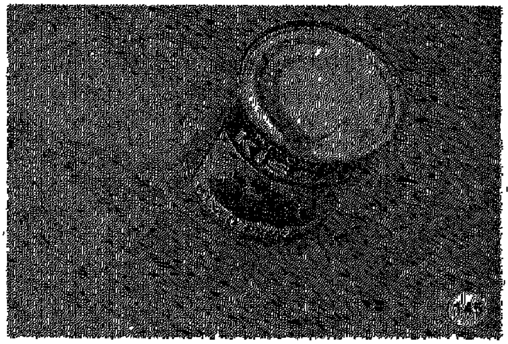

*Make A Pinhole Camera*

This is an unusual and interesting way of taking a picture

Get a tin can and make a nail-hole in the closed end (photo 144). Then make a small hole with a pin in a small piece of the metal foil from a cigarette packet and stick it over the nail-hole with a bit of soft clay or wax. Now there is only a tiny hole through which light can get in (photo 145).

Cover the open end with a stretched piece of very thin white paper on which you have melted some candle wax very thinly. Bind the paper with string so that it is like a drum skin. The picture will be made on this waxed paper.





Now, you must keep out all other light except what comes through the pinhole. So, wrap some dark paper (or a lot of newspaper) around the tin, so that only the end sticks out. The wrapping of paper must be at least 25 centimetres long because you must be able to put your eyes right to the end of it (photo 146) and see the picture in the darkness on the waxed paper. The wrapping must be thick enough to keep out all light, or it will spoil your picture (photo 147)

Now look in, with your face pressed into the tube of paper to keep extra light out. Point the pinhole end at a tree against a bright sky, and you will see a picture of the tree. It is always upside down.

You can make a brighter picture by making the pinhole bigger, but then the picture is not so clear. If you want to make the pinhole smaller, take the metal foil off and put on a fresh piece with a smaller pinhole in it. The nail hole on its own is much too big.

The shiny edges of the pinhole sometimes give you a bright sunspot in the middle of the screen. To avoid this, darken the pinhole by holding the foil for a moment in a smoking flame.

The pinhole camera works best if you are inside a building looking out through a window. Your eyes must get accustomed to the darkness in the camera before you can see the picture well.

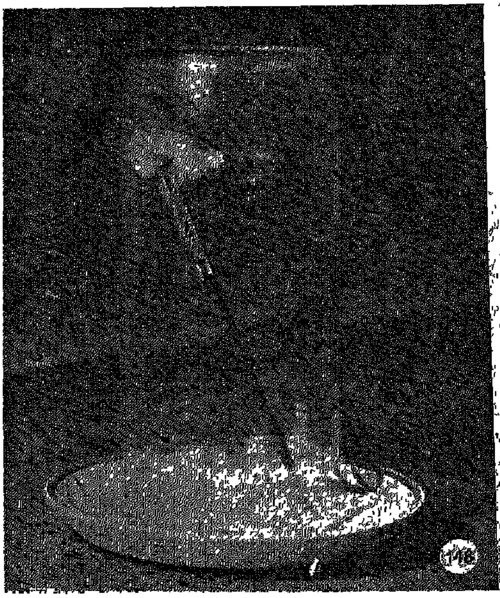
# Living Things

**Moulds, Insects and Plants**

*Mould And Bacteria*

Moulds and bacteria may produce diseases. They need food, dampness and warmth to grow. Bacteria and moulds are too small to see, unless they grow in large quantities Their seeds are also too small to see. They are in the air and on food, but they are especially thick and full-grown in dirt, on stale food and on things which have been in or on dirt, such as flies, cockroaches, dogs, etc They also grow on your hands if you do not wash them often.

Put a bit of stale food on a stick and push it up into a glass jar or bottle standing neck down in water (photo 148). Keep it in a warm place. The water keeps the air moist inside After a few days, a mould will grow so thick that you can see it, like a white or green fluff Take it out (do not touch it) and, holding the stick, dip it in boiling water for a while. Also wash out the bottle with boiling water. Then do the experiment again. You will find that it will take much longer to grow. Boiling kills it. If you have boiled and cleaned it all perfectly, it will never grow again.

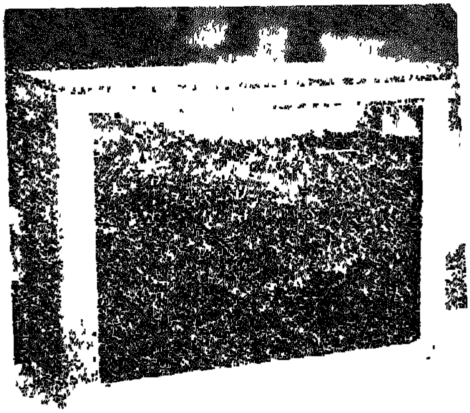


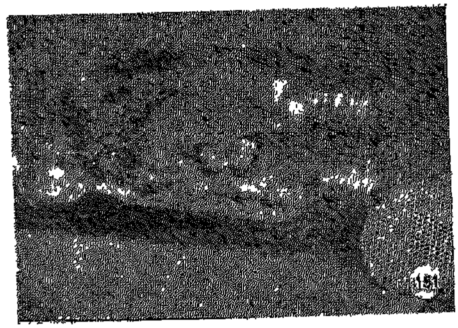
*Keeping Small Living Things*

The photo 149 show some water plants in a jar of water. Or, you could use a bottle or a clay pot (but then you would have to look in from the top). In this way, you can keep them in school and watch them grow. You may be able to see small bubbles of oxygen gas on the leaves This is what green plants breathe out.

If you can get glass, make a glass-sided box to keep burrowing animals or insects. It is full of soft earth as in the photo 150. You can keep worms or beetles that you find and you can see their nest holes under the earth through the glass. Ants are very interesting, but it is very difficult to avoid small holes somewhere around the top cover. So, they escape.

Larger insects are easy to keep in a bottle or a jar (photo 151) but its cover must allow air to get in or they die. Also, you must find out what their food is and make sure they have some each day. And do not let it get hot or too dry. In this way, you can watch how they live. Make the magnifier described earlier so that you can see them larger than life-size.





150

## Collection And Dissection

*Handling Small Thing*

To get some of the smallest creatures out of water, such as from a pool or a puddle, you need something that will suck them up with a little water. The photo 152 shows a device that will do it. Pull a short length of clear plastic pipe while heating the middle of it over a small flame. It begins to pull thin where it is hot. When it is thin enough at that place, let it cool, then cut it. So you have a short length of clear tube, narrow at one end as shown in the photo. Push this into a thicker piece so that its end just fits in air tight. Now block the other end with a wooden plug. If you squeeze the wide tube, put a narrow end into water, and release your grip, the wide tube will expand and suck water in.

Make a needle (photo 153) to help you pick flowers to pieces (using a magnifier) to see the parts they are made up of. Sharpen a piece of medium thick wire to a needle-point on a stone (photo 154). Then hold it in a piece of split wood, bound with thread (photo 153).

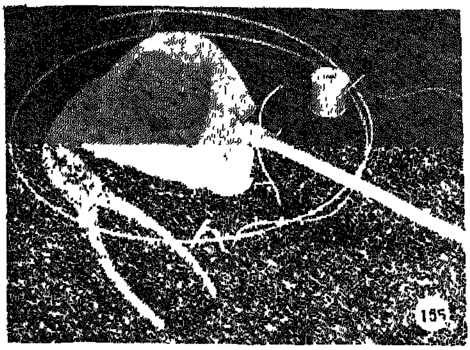
*Catching Insects And Fish*

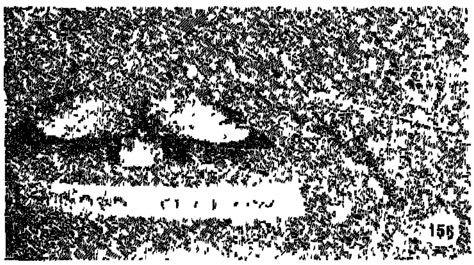
To collect butterflies, it is best to catch them with a net so as not to damage them The photo 155 shows you how to make one with soft cotton net hammed and threaded onto a wire. Then fasten the wire on to a long stick with string.

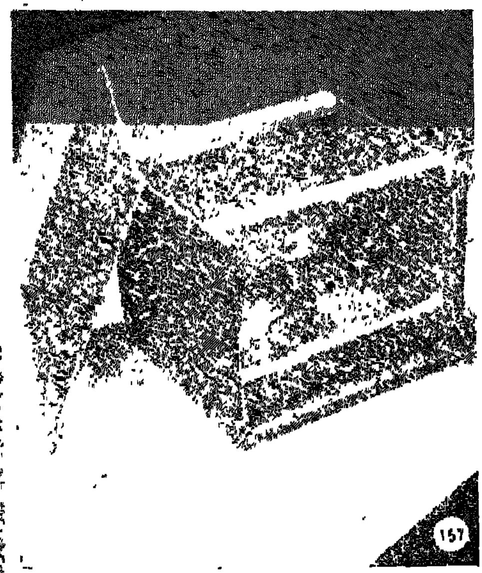
Mount butterflies so that you can look at them later by first laying them on a flat surface just after you have caught them Open their wings flat very gently and lay a small piece of soft cloth on them to keep their wings flat while they dry. Leave them in the sun until they dry (photo 156). If you try to spread their wings after they have been dead for several hours, their wings will crack.

*Collecting Moths*

Moths that fly at night can be attracted by a light Put a small lamp in a box (photo 157). Cover its flame with gauze. Make the front of the box of two sheets of glass, overlapping but with a gap so that moths can get in by crawling upwards. They cannot get out because when they crawl up the glass inside, the overlap is the wrong way. In the morning you will find you have caught some moths.







**Storing Leaves, Growing Plants**

*Make A Leaf Drier*

You can preserve flowers, leaves and small plants by flattening them in sheets of paper so that they dry (photo 158) Get two large boards and some dry newspaper. Put the leaves that you want to preserve carefully between the sheets of newspaper laid on one of the wooden boards Then put the other board on top, and either put a stone on it or hold the boards together with thick rubber bands cut from the inner tube of a car or truck tyre (photo 159). Or, you can bind them with string. Put it in the sun for several days to dry out.

*Watch Seeds Grow*

Put seeds against a sheet or two of damp paper inside a plastic bag, as shown in the photo 160. Or. put damp earth in the bag and make sure the seeds are against the clear plastic sides. After a few days you will see that the seeds begin to grow and you can watch the progress of the root and the shoot.

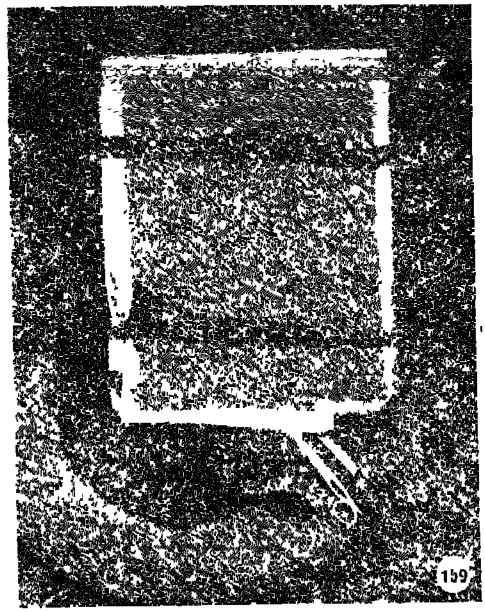
An easy way to keep these is to hang the bags on a wall shaded from the sun. Do not let them get dry. Put a few holes in the bottom of the bag so that if anyone puts too much water in, it will easily drip out.

*Plants Breathe Out Water*

Some experiments with plants need an airtight container for holding the plant, but one which you can see through For example, if you wish to see that plants give out water into the air around them, do the following experiment.

Make a large open coil of iron wire by winding it round a tin can or large bottle, and then pull it out to separate the turns. Put a plastic bag over it (Bend the wire ends inwards so that they do not pierce the plastic). Now, stand the plant you want to test on a large tin can. If you do not want water vapour to come out from the pot in which it is growing (as we do not do in this experiment), wrap the pot in a plastic bag too and bind it to the plant stem. Then put the plastic bag and the wire coil over the plant and bind it with string tightly to the tin can as shown in the photo 161. Leave it for the night. In the morning, when the bag is cool, you will find that water (that the plant gave out during the night) has settled on it inside

158



159

160

161

# Tools

*A Hammer*

For all the constructions in this book, a stone (photo 162) is a satisfactory hammer. The only exception to this is in the paragraph below where you need to flatten a nail. Perhaps you can do this at the blacksmith's.

*A Drill*

Flatten the point of a nail by hammering it. Also hammer the head flat until it looks like the nail in the photo 163. Then, push it hard into a strong hollow stick or a split piece of wood and bind it very tight with wire. Now, if you push and twist, you can drill holes in the wood with it. The flat head stops the nail moving in the handle.

*To Break Wire*

To break wire, grip it between two pieces of wood and bend it backwards and forwards many times until it breaks (photo 164) You can do this with your hands, but it takes longer.

*To Cut Wood*

If you want to cut wood neatly, you must borrow a saw You can also break the wood then trim it with a knife to make it neat.

*To Sharpen a Knife Pliers*

Keep your knife sharp by rubbing it on a flat sandy stone (photo 165) Put a little water on it first to make it easier and to help the particles of stone cut iron Keep testing it on a bit of wood until you can tell it is sharp. Get some advice from a carpenter or blacksmith about this.

*An Important Tool-Pliers*

Try very hard to get a real pair of pliers (with wire-cutters). To do the experiments of the kind described in this book, you will often need to use wire. It is possible to make the experiment without pliers, but it takes longer time and the wire hurts your hands.

# *APPENDIX I*

List of the participants of the two workshops organised by the Department of Education in Science and Mathematics, NCERT, New Delhi, in collaboration with UNICEF.

August 22 and 23, 1975 and
January 19 to January 22, 1976.

1. Shri B.K. Khanna, SISE, U.P., Allahabad.
2. Dr. B. Prakash, Vigyan Shiksha Kendra, Atarra Banda, U.P
3. Dr R B. Phansalkar, SISE, Maharashtra, Pune.
4. Shri V.K Shinde, SISE, Maharashtra, Pune.
5. Shri T K Suthar, Principal, Technical High School Kadi, Gujarat
6. Shri A.L. Dave, Science Unit, SIE, Gujarat, Ahmedabad
7. Shri V.K. Saxena, SISE, M.P., Jabalpur.
8. Shri O.P. Gupta, SISE, Punjab, Chandigarh.
9. Shri S.R. Agarwal, science teacher, collaborated with Shri O P. Gupta.
10. Shri H.C. Dutta, Research Officer, SISE, Bihar, Patna.
11. Shri Bordoloi, SISE, Assam, Gauhati.
12. Dr. P.K. Srivastava, Delhi University, representing Kishore Bharati.
13. Dr. V.S. Verma, Delhi University, representing Kishore Bharati.
14. Shri Kamal Mahendru, Kishore Bharati, Hoshangabad, M.P.

| NCERT | UNICEF | UNESCO |
|---|---|---|
| 1. Prof. A.N. Bose. | 1. Mr. G.K. Pillai. | 1. Dr. A.S. Everest. |
| 2. Shri N.K. Sanyal | 2. Mr D.R. Desai. | 2. Dr. O.L. Orekhov. |
| 3. Prof. B. Ganguly. | 3 Mr. Keith Warren. | |
| 4. Dr. B.D. Atreya. | | |
| 5. Dr. A.K. Misra. | | |
| 6. Shri P. Bhattacharya. | | |
| 7. Shri A.P Verma. | | |
| 8. Shri H.L. Sharma. | | |

# APPENDIX II

**Developmental work on use of local resources for primary science teaching**

The Science Education Programme, assisted by UNICEF, is under implementation in all the states. Many states have gone beyond the pilot and wider introduction phases and have started the universalization also. The introduction of new science curricula in all the schools of the states has raised an important question of providing a primary science kit to all the schools. Even if a state has got finances to do so, it will take some years before all the schools in a state can get a kit. There are 500,000 primary schools in the country (and their number will increase with the population growth) and that indicates the enormousness of the problem A new element has recently been added to teaching/learning at the primary stage. Under the new pattern of school education, the entire primary curriculum is being remodelled giving it an environmental approach This is intended to make education in the primary school more meaningful by relating it to the environment and day-to-day experiences of the learner—the child This additional factor creates a situation needing a second thought to the supply of primary science kit as it exists today to each and every school in the country. Experience and discussions with the people associated with the primary education during the last few months have revealed that teachers as well as the educators have welcomed the new trends in Indian education and have started using the environmental situations in the implementation of the primary school curricula. Thus, it becomes imperative for all of us to do some re-thinking as far as the primary science kit is concerned. People are getting more and more convinced that the science at primary stage can be more effectively taught/learnt if the existing learning situations available in the environment can be exploited to the maximum; in addition, while contriving the learning situations in the classroom, i.e. setting up experiments, more and more use of local resources can be made to make the learning more real and hence more effective. This has led us to the conclusion that more efforts should be made all over the country to help the teachers in making use of the environment in the learning/teaching of science. This can be done by providing suitable instructional material to enable a teacher to make best use of the learning situations which already exist in the environment: in addition, the teachers can be educated in setting up simple improvised apparatus by making use of the local resources to demonstrate certain principles of science

Certain amount of spadework has been done in this area by Department of Education in Science and Mathematics, NCERT

(a) Seminar, August 22 and 23, 1975

A Seminar was held in August 1975 to discuss this idea of using local resources for teaching of primary science. It was agreed that activities/materials for teaching science to primary classes as given in the NCERT science

syllabus classes I to V (1973) would be developed. It was decided that all materials on improvisation and use of local resources will first be tried out in a rural school.

The participants of the Seminar agreed to develop and try out materials as indicated below :

| | | Units of NCERT Primary Science Syllabus | Name of the State |
|---|---|---|---|
| A | 1. | Our Universe | Maharashtra |
| | 2 | Air. Water and Weather | Uttar Pradesh |
| | 3 | Rocks, Soils and Minerals | Uttar Pradesh |
| B. | 4. | Energy and Work | Punjab |
| | 5. | Matter and Materials | Uttar Pradesh (Banda) |
| C. | 6. | Living Things | Gujarat |
| | 7. | Plant Life | Bihar |
| | 8. | Animal Life | Gujarat |
| D | 9. | Housing and Clothing | Madhya Pradesh |
| | 10. | Human Body, Health and Hygiene | Uttar Pradesh (Banda) |
| | 11. | Safety and First Aid | Madhya Pradesh |

(b) Workshop, January 19-22, 1976

The workshop was inaugurated on 19th January, 1976 by Dr. A.N. Bose (the then Head, DESM/NCERT), who stressed upon the urgency of using local resources for improvisation and science teaching in view of the fact that many states have decided to enter the universalisation phase of the Science Education Programme at the primary level. Unless there is a cheap substitute to primary science kit. the teaching of science would continue to proceed by chalk-and-talk method because of the limited supply of funds for supplying kits

Mr. Keith Warren then made available to all participants a copy of his book "Science Experiments with Local Resources", published by Education Section, UNICEF, New Delhi, India. He discussed in brief how the materials were developed and to what use they can be put by the participants of the workshop. The participants from States contributed in terms of written instructional materials and improvised items. These were discussed and led to the following general remarks :

(i) Many resource books on the use of local resources for teaching science are available; but none of them works, in the sense that they are not used, teachers are just not convinced that they would work. For convincing them that it is very practicable, and to show how some children do it and others can if they so wish, it was suggested that posters based on a series of photographs of children actually doing activity be made available to teacher/children. These posters are likely to work better than mere discussion, demonstration or reading.

(ii) It was felt that changing the habits of an adult teacher is most difficult especially in view of the fact that they have 36 periods per week of teaching load and additional non-academic work. It was hinted that our major problem is to get these things—these ideas, put into practice by the teachers for primary science teaching.

(iii) The participants of the workshop felt that much of the material being presented was not new and already available in the books. It was decided that the presentation be restricted to new ideas or improvisations. The general feeling was that the workshop deliberations were getting too theoretical. Hence there was a need to finish this aspect of work (presentation of materials) quickly so that rest of the workshop time may be devoted to more practical work.

Five groups were formed to do an on-the-spot developmental work.

About twenty draft idea sheets were prepared and discussed on the last day of the workshop. Some samples are given in Appendix III.

The effort at this workshop was a sort of initial spadework, enabling us to take a further step to propagate and develop this concept at the State level. It was however felt that before the states can actually start thinking and doing something concrete in this area, there is an intermediate stage—to orient suitable persons selected from various states who can further develop the idea in relation to their own states. This is desired to be achieved through four regional workshops proposed to be organised during May to October 1977.

The grouping of the states for each region and the venue are as under ;

| Zone | States | Venue |
|---|---|---|
| Eastern | A & N Islands, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland. Sikkim, Tripura, West Bengal | S.I.E. Agartala (Tripura) |
| Western & Middle | Gujarat. Maharashtra, Goa, Madhya Pradesh, Rajasthan, Andhra Pradesh | S.I.E. Goa |

| | | |
|---|---|---|
| North and Upper | Haryana, Punjab, Himachal Pradesh, Jammu and Kashmir, Delhi, Uttar Pradesh, Bihar, Orissa, Chandigarh | S.I.E. Srinagar (J & K) |
| South | Kerala, Tamil Nadu, Karnataka, Pondicherry | S.I.S. Trivandrum (Kerala) |

The objectives of the proposed regional workshops are :

(a) To develop the concept of using learning situations available in the environment and improvisation of simple apparatus with locally available materials for activities in primary science ;

(b) To provide an opportunity to state level participants to orient themselves for the new approach through active participation in the workshops

(c) To develop a few samples of improvised apparatus and models with locally available material, and also related instructional material for the teachers;

(d) To provide to the States and Union Territories with suitably oriented resource/key personnel who, in turn, will orient the primary school science teachers as well as the educators of the Teacher Training Schools, to implement the idea in their own states.

The workshops will produce, in English, an appropriate detailed reports including a draft of instructional material, for teachers as well as teacher educators. These instructional materials will be consolidated and finalised in a national workshop. The states. subsequently, will use the instructional materials thus developed and the recommendations of the workshop for preparing suitable instructional material according to the states' own curriculum and local resources. It is hoped that this will largely be done through the active cooperation of primary teachers. This would help considerably in coordinating the future development envisaged at state level and in feeding the Department of Education in Science and Mathematics, NCERT with appropriate feedback.

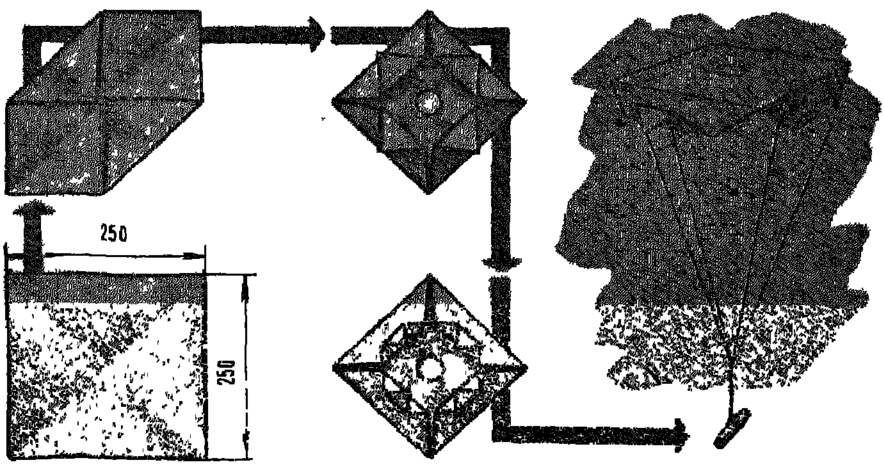
# *APPENDIX III*

## Samples of self instructional material for primary school children

### Make a Parachute

*Material used :* thick paper of size 250 × 250 mm, wooden stick of size 80 × 20 mm and four strings of 350 mm length each.

*Tools used :* scissors, knife, nail




**Procedure :**

*step 1* Take a thick paper of the size 250 × 250 mm

*Note :* If this size of paper is not available use paper from the exercise book. Fold the paper in such a way that its shorter side falls completely on its longer one Cut off small piece, i.e. remaining part of the paper which has not been folded. This will leave a square, the paper is opened out

*step 2 :* Fold each of the four corners of the square, so that they meet in the centre of the square. A new square is formed. Make a hole in the centre of the square.

*step 3 :* The four corners that meet in the centre are now folded back, so that each of them meets with its corresponding side of the new square. Again a new square is formed inside the first one.

*step 4 :* Take each corner again and fold it to touch the sides of the newly formed square.

*step 5 .* Make holes in the centre of all the four middle folds. To give the shape of a parachute you will push a string in each of these four holes. Knot should come to the upper side of the second fold in each case.

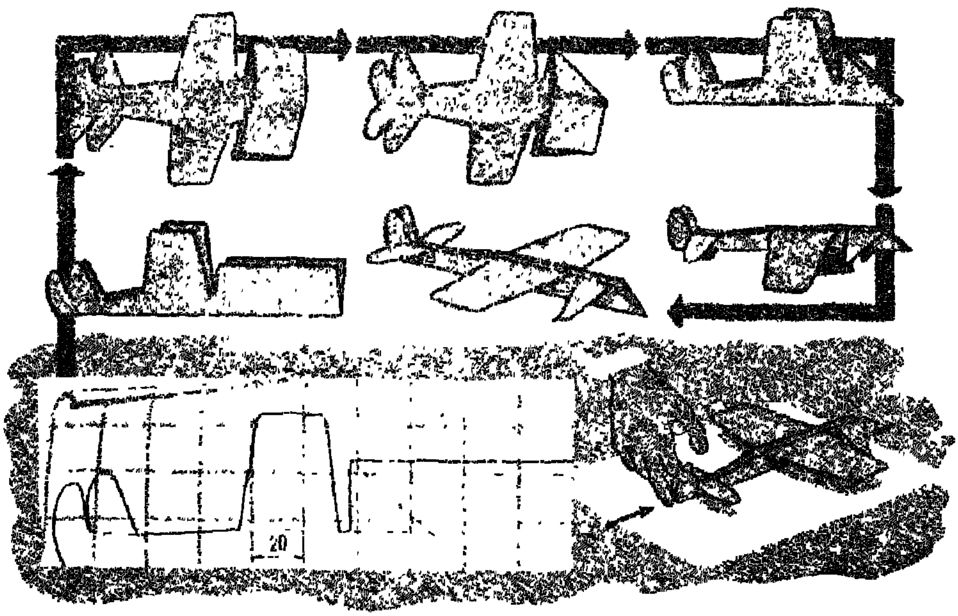
*step 6 :* Take a wooden piece and cut a small slit in the middle with knife or you can use a pebble.

*step : 7* Tie the four strings all together with the slit of the stick. Remember, that the length of four strings should be equal Parachute is ready, throw it up as high as you can.

**Make a Plane**

*Material used :* thick paper of size 200 × 160 mm

*Tools used :* scissors, scale, pencil




**Procedure :**

*step 1 .* Take a thick paper of the size 200 × 160 mm and fold it once from the middle of the two shorter sides. Lay down the folded paper on the table as shown in the diagramme. Divide the longer side (200 mm) of the upper rectangular fold into ten parts and the shorter side (80 mm) into four parts. Draw the

straight lines to make forty equal squares of size $20 \times 20$ mm. Draw sketch of a plane using squares on the paper as shown in the picture

*step 2 :* Cut out the sketch of the plane with the help of scissors Open the sketch of the plane and see that the front portion looks like a square.

*step 3 :* Now take the two outside corners of this square and fold them so that outside corners meet the two inner corners. You have halved the square into a rectangle.

*step 4 .* Again take the two outside corners and fold them so that they meet in the middle of the opposite side of the rectangle.

*step 5 :* Fold the sketch from the middle again.

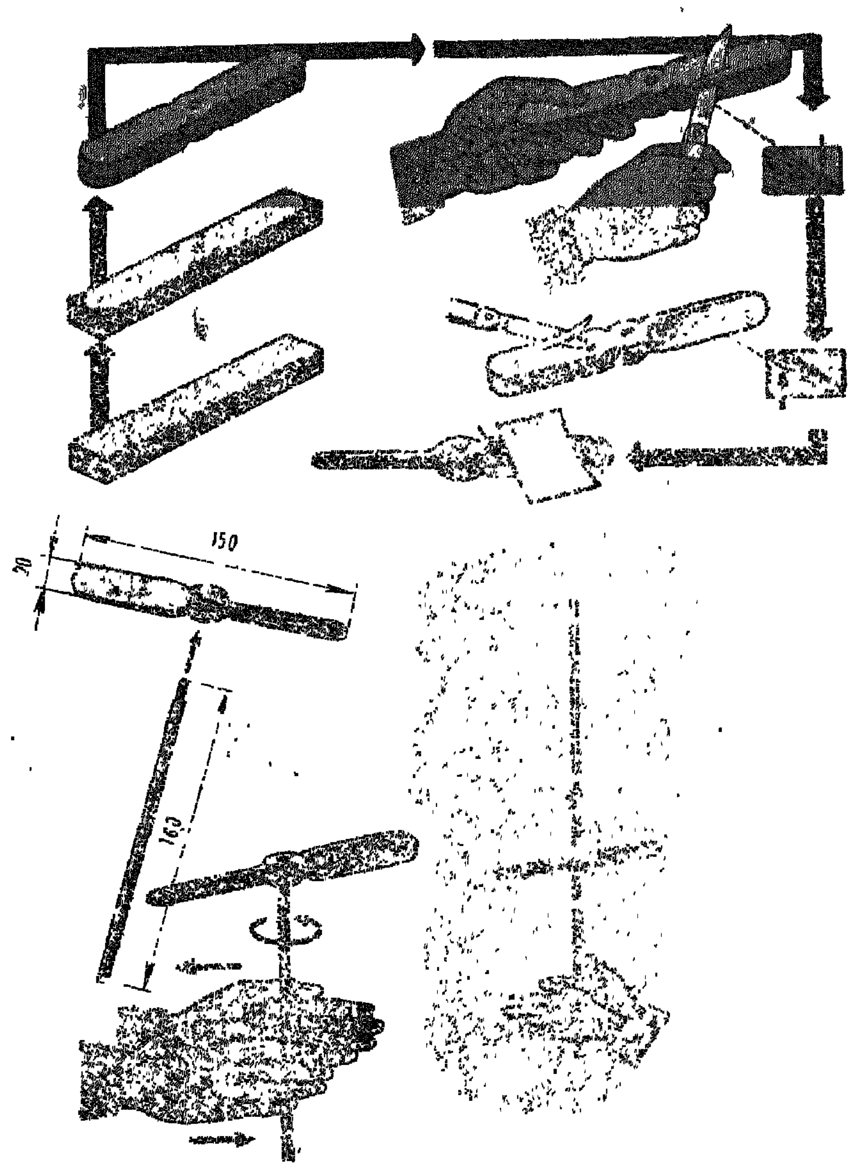
*step 6 :* Fold the four wings and front portion of this plane model downwards according to the dotted lines shown in the figure.

The plane is ready to fly, throw it up as high as you can or you can throw it from the ground. Remember that there should be enough open area for flying the plane. at least 5-7 metres.

**Make a helicopter propeller**

*Materials required* · Piece of soft wood of the size $150 \times 20 \times 10$ mm, wooden stick with length 160 mm and 5 mm diameter.

*Tools used :* knife, hand drill with bits. hacksaw, sand paper, pencil.




**Procedure :**

*step 1 :* Take a piece of soft wood of the size 150×20×10 mm. Put the wooden piece on the table, so that the face 150×20 mm will be up Mark the four central points of the four sides of this face. Draw straight lines to join the opposite points. The point at which the lines cross is the centre of the face.

*step 2 :* Draw the shape of a propeller on the face of wooden piece as shown on the figure and drill the hole with diameter 2.5 mm through the centre of the face.

*step 3 :* Cut with knife the edges, etc, to get a shape of propeller, as shown in the figure

*step 4 :* To make a right wing, chisel extra portion of right side of propeller with knife according to diagramme. Remember that first should be cut the top portion at angle 45°, and then bottom portion with the same angle but from opposite side.

*step 5 :* To make left wing of a propeller do the same with left side of wooden piece. Remember in this case you should start to chisel from the opposite side as shown in figure.

*Note :* Amount of wood chiselled from right and left sides of wooden piece should be equal.

*step 6 :* Smoothen the propeller with wooden sand paper.

*step 7 :* Take a stick of length 160 mm and diameter 5 mm, remove upper portion of stick with length 10 mm and make diameter 2.2 mm.

*step 8 :* Put the propeller upon the rod, a helicopter propeller is ready for use.

*step 9 :* Roll the rod with the help of the two hands as shown in the picture. Propeller will fly to the sky.

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